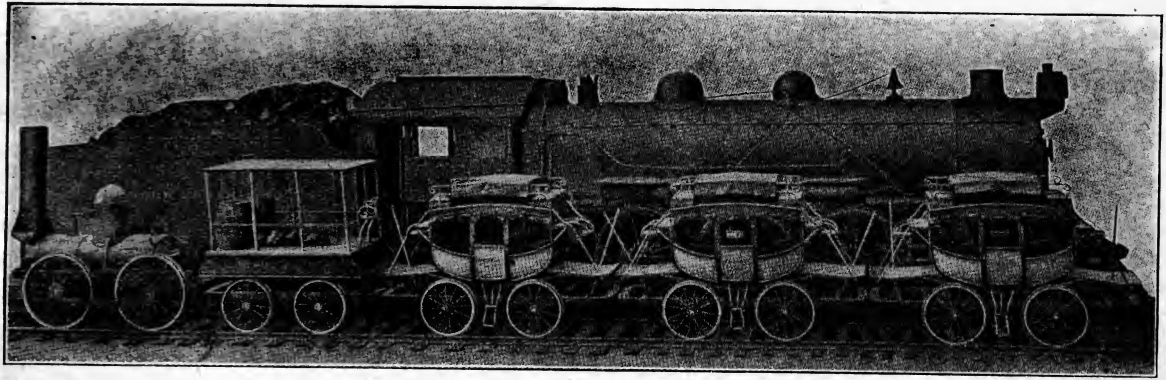
THE PRIMITIVE AND THE NEW IN RAILWAY LOCOMOTIVES



The above picture graphically illustrates the great advances that have been made in railway motive power within the memory of people now living.

The DeWitt Clinton, the first locomotive run in the State of New York, which, with its three primitive coaches, made its first trip between Albany and Schenectady on what is now a part of the New York Central & Hudson River R. R., August 9, 1831, is here compared with one of the Pacific Type passenger locomotives now in service on the New York Central Lines. It will be observed that the entire length of the first train just equals that of one of the present locomotives.

THE LOCOMOTIVES COMPARED

DeWitt Clinton	Weight with Tender	13,000 lbs.
Pacific Type	Weight with Tender	428,700 lbs.
DeWitt Clinton	Length, Locomotive and Train	80 feet.
Pacific Type	Length, Locomotive and Tender	80 feet, 7 inches.
DeWitt Clinton	Driving Wheels	4 feet, 6 inches in diameter.
Pacific Type	Driving Wheels	6 feet, 7 inches in diameter.

The Clinton attained a maximum speed of 15 miles an hour. The Pacific Type is the most powerful high speed locomotive ever built and will haul at a sustained speed of 60 miles an hour a train of 10 to 14 heavy Pullman cars.

Locomotive Reference

A Plain and Complete Treatise on the Modern Locomotive of To-day

Contains a Treatise on all types of Steam Locomotives, covering Breakdowns and Methods of Handling Same, giving a Thorough and Practical Knowledge of Firing and Running, also Construction of the Present Day Type of Locomotives, Along with an Exhaustive Treatise on Valve Motions, Including the Walschaerts and Baker-Pilliod and Baker Improved Valve Gears, also the Southern Valve Gear, Along with Simple, Compound and Piston Valve Engines, Combustion, Boiler Feeding, Lubricators and Injectors, Oil Burning Engines, Also a Treatise on the Electric Headlight, Superheater, Air Doors and All the Latest Locomotive Appliances, Also a very Complete List of Questions and Answers Identical with Those in use on many of the Railroads Throughout the United States and Canada, for the Employing of Engineers and the Promotion of Firemen

BY

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Annis Ready Reference for Enginemen, and Modern Locomotives and Air Brakes by Annis.

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PREFACE

The contents of the following pages is designed to give to the Locomotive Engineers, Firemen, Machinists, Air Brake men and all others whose duties demand a practical and technical knowledge of the modern locomotives of today, covering pointers for all who have chosen railroading as their life's work. And if the information contained in these books meets with the success as my other books, which have been used by many of the railroad men of the United States and Canada for the past twenty years, and helps the student and more advanced employe, who is seeking knowledge and a better understanding of his chosen walk in life I will feel amply repaid for the time spent in preparing this work, in which I have done my best to make plain and authentic, using only the plainest terms found in the English language and taking up and treating such subjects as to me seemed to be of the most value to my readers and which I trust will aid them in holding positions they now occupy and assist in fitting them for higher and better ones. My effort has been to make these two books much more complete and concise than any of my books heretofore, and like my other books, I have drawn largely from my own practical experience as accumulated in my thirty-five years of service in the transportation and motive-power departments of some of the leading railroads of this great country. I have also had access to the leading railroad and mechanical and scientific journals published, from which I have gleaned such information as I thought would add to and make the work of more value to my readers, who by study and perseverance and a desire to excel and attain the highest pinnacle in his chosen work, and with many thanks to the readers of my other books of past years and if this, my latest effort only meets with as favorable approval as my others have I am amply repaid. Trusting the within pages will assist the reader to the sought-for information, I am

Most truly yours,

THOS. A. ANNIS,

Adrian, Mich.

THE LOCOMOTIVE BOILER, CONSTRUCTION AND OPERATION

The locomotive boiler is a vessel cylindrical in form, made of steel sheets or plates, and has a rectangular shaped fire-box at one end and a smoke-box at the other, on which is placed the smoke-stack. The smoke-box at the front end and the fire-box at the back end are connected by tubes or flues, which conduct the smoke and sparks, etc., from the fire-box to the smoke-box, thence to the atmosphere, by aid of the draft through the smoke-stack.

This style of boiler is known as a tubular boiler, having an internal fire-box and a barrel with tubes extending through it to the smoke-box. As the heat from the fire-box passes through the tubes or flues,

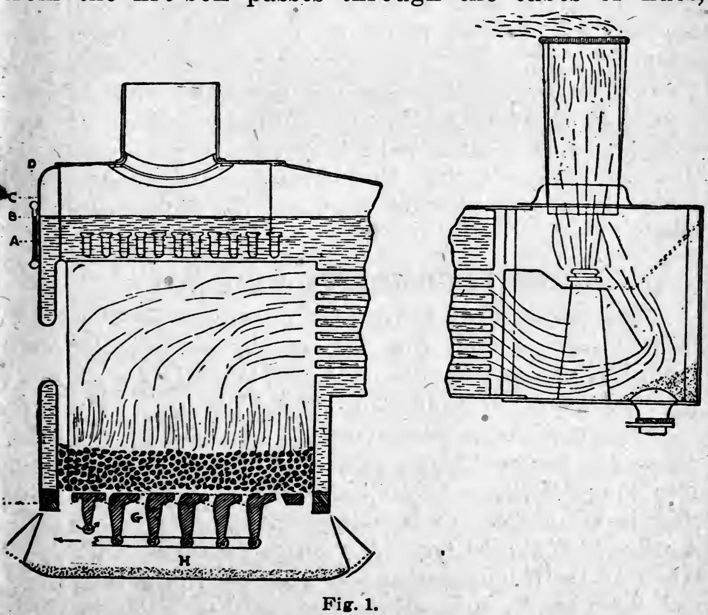


Fig. 1.

it brings the greatest possible heating surface in contact with the water, and thereby assists to convert the water in the boiler into steam. (See Fig. 1.)

Steel plates are used in the construction of the boiler. These plates are carefully tested for defects before being used, and are subjected to a test for tensile strength of from 55,000 to 65,000 pounds per square inch, with an elongation of about 25 per cent.

The plates are bent and forged into the proper shape, and then securely riveted together.

Single riveted lap joints have about 56 per cent of the strength of the plate. Double riveted lap joints have about 75 per cent of the strength of the plate.

Butt joints are used for longitudinal seams. Lap joints are used for circumferential seams.

The butt joint is one in which the edges of the plates are butted together on the same plane and the seam overlaid with a strip of plate and riveted by one or two rows of rivets on each side of the center seam.

Circumferential seams are generally riveted with two rows of rivets, while longitudinal seams are riveted with three and often with four rows. The reason for this difference is that the strain on the longitudinal seams is nearly double that on the circumferential seams.

THE LOCOMOTIVE FIRE-BOX.

The fire-box of the modern locomotive is rectangular in shape (See Fig. 2.), and is constructed with five different sheets—two side sheets (E), crown sheet (U), back sheet (C), and flue sheet (Y).

The fire-box is placed inside of the outer shell of the boiler, the two being joined at the bottom by means of a large ring or frame, called the mud ring. This ring is from four to five inches thick, and separates the fire-box sheets from the outer shell the same distance of its thickness, and is secured there by rivets. The door sheet, side sheets and part of the flue sheet are fastened to the outer shell of the fire-box by means of stay bolts screwed through both sheets and riveted on both ends.

Hollow stay bolts are used so that a broken bolt can be detected by escaping steam from the drill hole

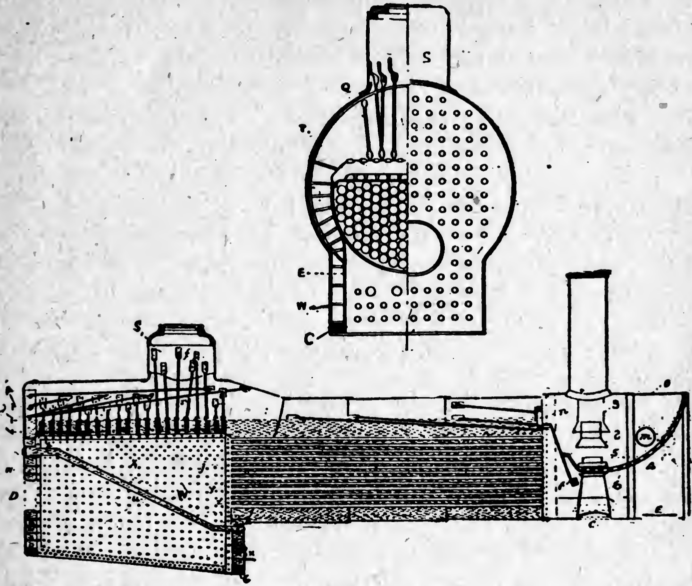


Fig. 2.

in the bolt, which is there for that purpose. The attachments below the mud ring are the grates, ash pan, grate levers and the drop or dump grate.

The Crown Sheet—Is supported by means of the crown bars and radial stays, the crown sheet being from 18 to 24 inches below the top shell of the boiler. Stay rods are attached to the boiler head and outer shell of the boiler and to the flue sheet and the outer shell for the purpose of taking up some of the lateral strain on these parts. These are called radial stays.

Crown Bars—Are those that support the crown sheet (See T, Fig. 2). Sling stays are supports extending from the crown bars to the outside shell of the boiler (See Q, Fig. 2). The worst feature to the use of crown bars is the difficulty of keeping them clean, due

to the fact that mud collects between the crown sheet and bars, thus endangering the sheet by overheating.

Radial Stays—Are generally considered better than crown bars as they can be more easily kept free of mud and are more economically repaired, also allow better circulation of the water in the boiler.

Circulation of the Boiler—Is a term applied to the movement of the water in the boiler when heated.

The water, coming in contact with the heated sheets and flues, is converted into steam and rises to the top and other water takes its place, thereby causing the water to change places, or circulate. For the best results in a boiler it must have good circulation and should be clean and free of mud, scales, etc.

The water leg of a boiler is the space between the outside and inside sheets of the fire-box.

The dome is placed on the top of the boiler for the purpose of allowing the steam to rise some distance above the water level, thus freeing itself of some of its moisture before entering the dry pipe through the throttle valve, which is generally placed in the dome.

Wagon Top Boiler—Is one that the fire-box end is much larger than the cylindrical part, and is so built to provide more dry steam space. That part of the boiler extending from the barrel to the lower edge of the fire-box is called the throat sheet. The cylindrical part extending from the fire-box section to the smoke-box is called the barrel.

Underneath the smoke-box is attached a spark hopper for getting rid of the sparks that are accumulated by the netting which is placed in the smoke-box, and prevents the hot sparks being thrown out along the road, causing damage by fire.

A draft sheet, or apron, which is to regulate the draft through the fire so that it may burn even all over the grate surface, also the steam pipes which convey the steam from the dry pipe to the steam ports in the cylinder saddle, are in the front end, or smoke-box.

There are hand holes in the sides of the smoke-box for use in cleaning the sparks out.

There are washout plates and plugs arranged at different places in the shell of the boiler for convenience in washing out the mud and scale which accumulate in the boiler from the water used.

A blow-off cock is placed in the lower edge of the throat sheet for the purpose of draining the steam and water out of the boiler.

A safety valve is attached in the top of the dome, and this is set to relieve the pressure in the boiler when it exceeds the pressure desired. The boiler is placed horizontally on steel frames to which the engine's running gears, etc., are attached. The boiler check is generally placed near the front end of the boiler so as to introduce the feed water at as great a distance as possible from the fire-box. The advantage thereby gained is that it allows the water to become partially heated before coming in contact with the hot sheets, and it also has a tendency to cause better circulation in the boiler.

The Abuse of a Boiler.—Sudden changes in fire-box temperature cause a sudden contraction and ex pansion of the flues and sheets, and this causes the flues to leak and sheets to crack. Other abuses are allowing the steam pressure to drop back the generating steam quickly by the use of the blower. Improper firing, over pumping or anything that will cause sudden changes of the temperature of the fire-box come under this head.

LOCOMOTIVE DRAFT APPLIANCES

HOW THE DRAFT IS CREATED.

The exhaust steam creates a draft on the fire by forming a partial vacuum in the smoke-box. The air from the fire-box is drawn through the flues, causing a draft on the fire, and in turn fresh air is forced by atmospheric pressure through the grates to supply the fire.

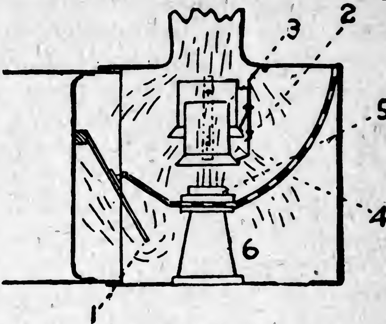


Fig. 3.

THE APPLIANCES.

The draft appliances of a locomotive, as shown in Fig. 3, are diaphragm (1), petticoat pipe (2), adjustable sleeve (3), netting (4), exhaust nozzle (5), and exhaust stand (6).

The diaphragm is a sheet of steel fastened at an angle just above the top of the boiler flues, or tubes, which deflects the smoke and sparks toward the bottom of the smoke-box. Fastened to the stationary part of the diaphragm is another section, generally hinged in modern engines, which, when raised or lowered, regulates the draft through the flues. Raising the diaphragm increases the draft through the upper flues and decreases the draft through the lower ones. Lowering the diaphragm has a directly opposite effect.

The petticoat pipe (2), which is cylindrical in shape, is set directly over the exhaust nozzle (5), and has a second tube of larger diameter (which is called the adjustable sleeve) (3), above, so as to telescope with it. They are arranged in a direct line with the stack and act as a guide for the steam from the exhaust nozzle in its passage out of the stack.

Raising the sleeve and lowering tne petticoat pipe decreases the draft on the fire. Lowering the sleeve and raising the petticoat pipe increases the draft on the fire. If the fire burns stronger at the fire-box door, it indicates that the draft is greater through the upper flues. If it burns the strongest at the front end of the fire-box it shows that the draft is greater through the lower flues.

The netting (4), shown in (Fig. 3), is a wire net, or screen, fastened to the smoke-box to prevent the sparks and cinders from passing out of the stack. The smoke, gases and small cinders passing through the flues are deflected downward by the diaphragm, then pass through the netting which prevents the larger sparks and cinders from escaping and causes them to collect in the bottom of the smoke-box (See Fig. 1). After the cinders are broken into fine particles by being dashed against the netting they mostly pass out of the stack with the smoke and gases.

The exhaust steam from the cylinders converges in the nozzle stand (6), and to the top of this stand the nozzle is fastened by means of bolts or set screws. The nozzle is a guide for the exhaust into the petticcat pipe, sleeve and stack. The larger the size of the nozzle, the less severe will be the draft on the fire. The smaller the nozzle, the more severe the draft.

Adjusting the Petticoat Pipe.—By increasing the space between the nozzle and the petticoat pipe and between the base of the stack and the sleeve, a larger space is provided for the gases to pass from the front end. By decreasing the space it gives a directly opposite effect. Should the exhaust appear strongest on one side of the stack, it is an indication that the exhaust stand, petticoat pipe, sleeve or stack are not in line. (See Fig. 2.)

Other Indications.—If upon opening the fire-box door you find what is commonly known as a red fire, it is a very good indication that the grates are clogged with ashes and clinkers. The pull on the fire-box door is another indication of the clogging of the grates, be-

sides the clogging of the grates and derangement of the draft appliances. Clogged netting and leaking steam pipes will cause the fire to appear red. A leaky steam pipe or a leaky exhaust stand gasket will cause the engine to steam poorly, as the escaping steam in the smoke-box takes up the space that should be filled with air from the fire-box.

THE BLOWER.

The apparatus called a blower is to create a draft through the fire while the engine is not working steam or is standing still, and this is accomplished by passing steam through the blower in such a way that it will escape up the stack in a steady jet, as nearly central as possible. The blower cock is generally attached to the top of the boiler inside the cab, and is connected with the front end by means of a pipe. The action of the steam in creating a draft differs some from the action of the exhaust in accomplishing the same end. Steam from the blower escapes in a continuous jet through the stack. Therefore, the plunger-like action of exhaust steam when the engine is working slow is not present, the draft being induced principally by the friction of the particles of steam against the particles of the gases in the smoke-box and stack.

When and How to Use the Blower.—In putting in a fire while the engine is standing the blower should be opened lightly before opening the fire door, as by so doing the gases in the fire-box will be kept from pouring out of the door into the engine cab. The blower should always be used as little as possible, and should not be used at all after the fire has been drawn, as it will induce a current of cold air to be drawn in, which will cause the sheets and flues to cool too rapidly, thereby causing leaks.

WORK IN HARMONY.

Of all the causes that make an engine steam badly, improperly adjusted draft appliances are probably the most common. However, no set rule can be laid down

for their adjustment, as what will cause one engine to steam well may not apply to another.

The manner of feeding and firing a boiler has much to do with its steaming qualities. To get the best returns, these two operations should be performed in harmony. That is, the engineer should try to feed the boiler in such a way as to assist the fireman as much as possible, and the fireman, on his part, should see that a good bright fire is maintained, especially when the injector is being used, and both the boiler feeding and firing should be performed according to the latest approved methods. The fireman may be ever so capable, and do his best to better his coal record, but if the engineer does not perform his work in harmony and with a view to economy, the fireman's efforts will not amount to much.

STEAM GENERATION.

Steam is an invisible gas formed or generated by heating water above the boiling point. The water, coming in contact with the heated sheets of the boiler, rises to the surface in the form of bubbles, where they explode in the form of steam, and is considered the source of power of the steam locomotive.

Steam as Indicated by the Steam Gauge.—The pressure shown by a correct steam gauge means the pounds per square inch above the atmospheric pressure. By the atmospheric pressure is meant the weight of the atmosphere which surrounds the earth. Atmospheric pressure is estimated at 14 7-10 pounds per square inch at sea level.

DEFINITIONS OF TECHNICAL TERMS.

Absolute Pressure—Of steam is its pressure reckoned from a vacuum, the pressure shown by the steam gauge plus the pressure of the atmosphere.

Boiler Pressure—Is the pressure above atmosphere, the pressure shown by a correct steam gauge.

Initial Pressure—Is the pressure in the cylinder at the beginning of the forward stroke.

Terminal Pressure—Is the pressure that would be in the cylinder at the end of the piston's stroke if release did not take place before the end of the stroke. It can be determined by extending the expansion curves to the end of the diagram, or by dividing the pressure at the cut-off by the ratio of the expansion.

Mean Effective Pressure—Is the average pressure against the piston during its entire stroke in one direction less the back pressure.

Back Pressure—Is the loss in pounds per square inch required to get the steam out of the cylinder after it has done its work. In a locomotive it is shown by the distance apart of the atmosphere and counter pressure lines.

Total Back Pressure—Is the distance between the lines of counter pressure and of perfect vacuum represented in pounds.

Initial Expansion—Is shown by the reduction of pressure in the cylinder before steam is shut off.

Ratio of Expansion—Would be the ratio of the fall in pressure between the cut-off and the end of the stroke, providing there was no exhaust.

Wire Drawing—Is the reduction of pressure between the boiler and cylinder. It often causes initial expansion. It is caused by contraction of steam pipes or ports.

Clearance—Is all the waste space between the piston and valve when the piston is at the end of its stroke.

A Unit of Heat—Is the heat required to increase the temperature of one pound of water one degree Fahrenheit when the temperature of the water is just above the freezing point.

A Unit of Work—Is one pound raised the height of one foot. One unit of heat equals 772 units of work

One Horse Power—Is 33,000 pounds lifted a height of one foot in one minute, or one pound lifted 33,000 feet in one minute, or vice versa.

Indicated Horse Power—Is the horse power shown by the indicator. It is the product of the net area of the piston, its speed in feet per minute, and the mean effective pressure, divided by 33,000 pounds.

Net Horse Power—Is the indicated horse power, less the friction of the engine.

Saturated Steam—Called dry steam, that contains just sufficient heat to keep the water in a state of steam.

Superheated Steam—Is steam which has an excess of heat which may be parted with, without causing condensation.

Compression—Is the compressing of the unexhausted steam in the clearance space by the piston after the exhaust closure.

Latent Heat—Is the quality of heat expressed in heat units required to evaporate water already heated to the temperature of the steam into which it is to be conducted.

Sensible Heat—Of steam is its heat as shown by a thermometer.

Piston Displacement—In the space reckoned in cubic inches swept through by the piston in a single stroke. It is found by multiplying the area of the piston in inches by the stroke in inches.

THE MODERN LOCOMOTIVE. ITS CONSTRUCTION AND FUNCTION OF THE PRINCIPAL PARTS

Having pretty thoroughly covered the boiler, firebox and draft appliances, we will now take up the engine, and proceed with each part in its turn, giving a plain and concise treatise of the same.

THE SIMPLE ENGINE.

While there are a great many different designs and classes of locomotives, there are only two engines used, and they are known as the simple and compound engine.

The simple engine is one that admits steam to the cylinders a given part of its stroke, and allows its expansion during the balance of the stroke, then exhausts to the atmosphere. A simple locomotive is double-acting, single expansion, non-compounding and non-condensing. The locomotive consists of two engines attached in a horizontal position to each side of a heavy frame that supports the boiler. The two engines are connected by rods attached to crank-pins on the driving wheels, which are fastened solid to the main shaft or axle, and are so constructed that they work in perfect harmony with each other. When one engine is passing the center or dead points, or at the end of its stroke, the other engine will be exerting its full power. Thus it is impossible for both engines to get on the center or dead points at the same time.

The locomotive is so designed that it furnishes its own tractive power as well as power to draw a heavy load. The engine cylinders are connected to the barrel of the boiler smoke-box and frame in such a way that the steam pipes in the front end may be connected to the part of the cylinder casting known as the cylinder saddle, which has ports cast in it to conduct the steam from the boiler through the steam pipes to the steam

chest, also a port to conduct the steam after being used in the cylinder through the exhaust passages to the stack, thence to the atmosphere. There are two other ports in the cylinder casting, one at each end of the steam chest or valve seat, which also connects with each end of the cylinder. Through these ports the steam is admitted (by the main valve in the steam chest) into the cylinder, and after performing its work there, is again exhausted through the same port by the movement of the main valve. A piston head and rod are placed in the cylinder. On one end of the rod which passes through a suitable hole in the back cylinder head is placed the piston head, the other end of the rod being attached to a cross head, which works in guides fastened to the cylinder casting and guide yoke, one end of the main rod being also connected to the cross head, while the other is connected to the pin in the main driving wheel, thus changing the reciprocating, or to-and-fro, motion of the piston to a circular motion. On admission of steam to the cylinder, it presses against the walls of the cylinder, the cylinder head and the piston. The piston being the point of the least resistance, it will be forced to move. Thus the movement is transmitted through the main rod to the crank pin and wheel to which it is attached. Should the crank pin be at a point of its circle which forms an angle to the center line of motion of the main rod, the force which the steam exerts against the piston will be exerted against the pin, forcing it to move in a circle around the axle.

Should the pin be in a line with the center of the axle and the forward end of the main rod, it would not move, as the force is exerted directly against the center line of motion.

Each engine has two centers, known as the forward and back center. The engine is on its forward center when the piston has completed its forward stroke, and on its back center when the back stroke is completed.

The forward and back centers of an engine are often called the dead points of circular motion. When the engine is started the crank pin of one engine is forced over or carried past the dead points by the engine on the opposite side. Thus, while one engine is at rest, or on its dead points, the other is exerting its full power.

THE COMPOUND ENGINE.

The compound engine first admits steam to its high pressure cylinder, where it is partly expanded in doing its work, and then exhausted into the steam chest of another larger cylinder, called a low pressure cylinder, where it completes its expansion, and then is exhausted through the stack to the atmosphere. The compound engine is double-acting, double-expansion, non-condensing, compounding. The compound engine is considered economical from the standpoint of consumption of fuel, but the cost of maintenance and the frequency of its failures on the road have been the causes of many railroads discarding them in favor of the simple engine.

ENGINE TRUCKS.

The engine truck, the style of which varies according to the design of the engine on which it is used, is placed under the forward end of the main frame, to help carry the weight and to guide the engine. Some trucks have only two wheels and are called pony trucks. They carry the weight on a frame that rests on two bearings, which are inside the wheels. With this style of truck the front end of the locomotive frame is pivoted on the center of the truck frame. Other trucks have four wheels and are called bogie, or engine trucks. This design of truck has a rectangular frame supported by semi-elliptical springs suspended from equalizers, the ends of which rest on the

truck boxes. They have a center plate, which is placed in the center of the truck frame, and upon this the front end of the engine is pivoted so as to allow it to turn with the curvature of the track. This style of truck is generally used by engines in high speed service.

DRIVING WHEELS.

Driving wheel centers are generally made of cast steel. A steel tire is then turned out a trifle smaller than the circumference of the wheel center. This tire is heated, which causes it to expand until large enough to slip over the wheel center, when it is cooled, causing it to shrink on with great pressure.

COUNTERBALANCES.

The driving wheels of locomotives are provided with counterbalances, and are used for balancing the weight of the rods and connections, and are placed as near the rim of the wheel as possible and opposite the crank pin, and cause the wheel when revolving to turn with a steady motion. In this way the throw, or unequal energy exerted by the centrifugal force of the parts in motion, is overcome, but the reciprocating parts and their weight, or the inertia caused by the dragging or friction of the parts, cannot be equalized by adding counterbalance, except in one way, as it would have the same tendency to overbalance the wheel vertically to the same extent that they balance the reciprocating parts horizontally. Therefore, any additional overweight in the counterbalance that is not needed to balance the parts so as to produce a good riding engine is a detriment, not only to the engine itself, but to the bridges and track that the engine runs over.

DRIVING AXLES.

The driving axles of the locomotive are made of steel and carefully tested for tensile strength and for

defects. They are now made without any shoulder inside of the journal, with the center usually a little smaller than the journals. The wheels are pressed on the axles with a pressure of from 60 to 70 tons, after which they are keyed to the axles.

DRIVING BOXES.

Driving boxes are made of cast iron in the shape of an inverted letter U, and are provided with bronze crowns. The boxes are placed on the axle just inside of the wheels, and have bearings on the axles to carry the weight of the locomotive. They also have bearings on the side against the hub of the wheel to prevent too much lateral motion or side play. The boxes are placed between the jaws of the frame, or pedestal, and shoes are placed between the pedestals and the boxes to prevent wear of the frames. There is an adjustable wedge placed between the shoe and the pedestal at the back of each driving box. This wedge can be moved up or down by means of a screw or bolt, threaded in and passing through the pedestal cap. A jamb nut is used to prevent this adjusting bolt from working loose. The lost motion in the box is taken up by adjusting this wedge. An oil cellar is placed under the axle between the jaws of the driving box. This cellar is filled with wool waste well saturated with oil to lubricate the journal, and in many cases hard grease is used instead of oil and waste. The box has oil holes drilled down through the top and the crown brass. A little waste is put on top of the box and soaked with oil, and the oil feeds gradually through the oil holes, thus helping to keep the journals lubricated.

SPRING SADDLE.

The spring saddle, which is placed on top of each driving box astride the engine frame, is used as a support for the engine driving springs.

DRIVING SPRINGS.

The driving springs are made of spring steel, and are made up of a number of leaves or flat strips, and are bound together by a band of iron around the center. The springs are used to modify the amount of shock which without them would be imparted to the frames and engine when the wheels run over rough or bad places in the track.

SPRING HANGERS.

The spring hanger is the slotted bars of iron that connect the ends of the springs with the equalizers and frame.

THE EQUALIZERS.

The equalizer is used to equalize the weight between two or more parts. With engines having trailers the equalizer is used to connect the trailer with the main springs, thereby causing the engine to ride easier and reducing the liability of breakage. When the engine truck strikes a rough place in the track a part of the shock is transmitted through the long truck equalizer to the front driving springs.

A CHAPTER ON VALVE MOTIONS

TRACING THE STEAM FROM BOILER TO ATMOSPHERE.

The accompanying cut (Fig. 4) shows an interior view of the boiler throttle, stand pipe, dry pipe, and steam pipe; also the manner in which they are connected.

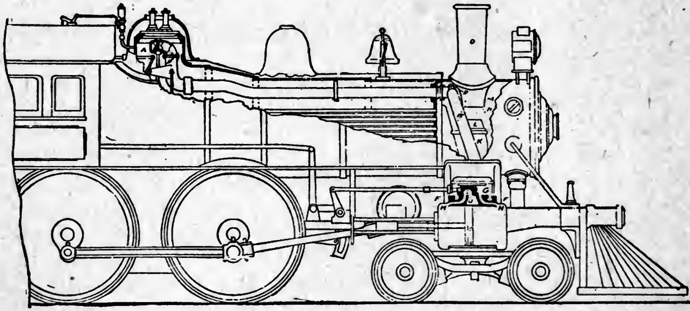


Fig. 4

When the throttle is open steam passes by throttle valve A in the dome, through stand pipe B to dry pipe C, through the dry pipe to the niggerhead D in the smoke arch, and thence through the steam pipes E to the steam passage F in the cylinder saddle, and to steam chest G. When the port is uncovered by valve H for the admission of steam to the cylinder, the piston is forced to the opposite end, thus transmitting its power to the cross head and main rod, thence to the pin, wheel and rail, and from the journal and eccentric to the valve motion, giving the forward and backward motion to the valve, shutting off the admission of steam to the cylinder and opening the exhaust port J just before the piston has completed its stroke. The steam then passes out through the same steam port H through which it entered, either by the end of the inside admission piston valve or through the exhaust cavity I to the exhaust passage J, through exhaust

stand K and nozzle L, through petticoat pipe M and sleeve N, if used, to the stack O, and out to the atmosphere.

STEAM ADMISSION.

Steam is admitted to the steam-chest through to passages A A (Fig. 5). They are called steam passages, and are cast in the cylinder. These passages terminate in a smooth flat surface B B, called the valve-seat. The openings C C are the steam ports. Between them is cavity D, called the exhaust cavity, and the exhaust arch E is directly over this.

The shape of the ports is long and narrow as shown in Fig. 5. Over these ports is the valve V, which is generally made of cast iron, and so constructed that by moving it backward and forward its movement will alternately cover and uncover the steam ports C C. The valve and seat are inclosed in the steam-chest, to which steam is admitted from the boiler through the dry pipe.

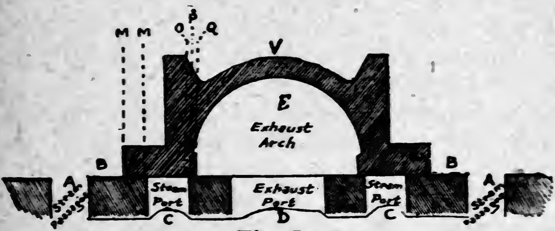


Fig. 5

STEAM EXHAUST.

Each engine exhausts twice during one full revolution of the driving wheels. When the right hand cross-head has moved back from forward center to nearly the middle of the guides, the left engine is exhausting on its forward stroke. When the right hand cross-head reaches a point close to the back end of the guides, the right engine is exhausting on its backward stroke. When the cross head on its return movement has nearly reached the middle of the guides, the left engine is exhausting on its backard stroke, and when the cross head is nearing the forward end of the

guides, the right engine is exhausting on its forward stroke, making four different exhausts for each full turn of the driving wheels, two exhausts for each engine.

When the valve is in the position shown in Fig. 6, the front steam port C is uncovered and the steam is admitted to the front end of the cylinder, as shown by the curved arrow, and forces the piston toward the back end. Fig. 7 shows the valve at its extreme travel, with full port opening. The operation of a piston valve is similar to that of the slide-valve, except that a piston valve works in a bushing instead of on a flat surface.

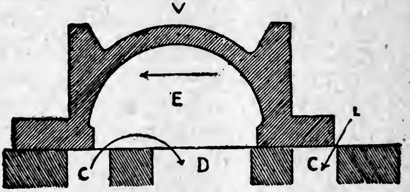


Fig. 6

When the piston reaches the back end of the cylinder, the valve has been moved to the position shown in Fig. 8, the back steam port C will be uncovered and steam will be admitted to the back end of the cylinder, as shown by the curved arrow. At the same time the front steam port C and the exhaust port D are both uncovered by the cavity E in the slide-valve, so that the steam which was admitted to the front end of the cylinder can now escape.

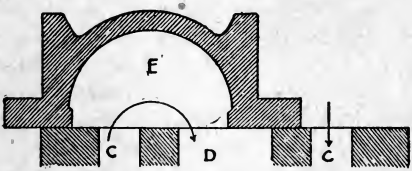


Fig. 7

As shown by the arrow, through steam port C into exhaust port D, and thence to the atmosphere. Thus, by the movement of the slide-valve alternately back and forth, steam is simultane-

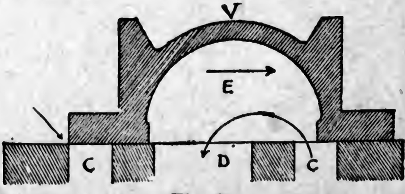


Fig. 8

ously admitted to one end of the cylinder and exhausted from the other, and vice versa.

LEAD AND LAP.

The width of the opening of the steam port to admit steam into the cylinder, when the piston is at the beginning of the stroke (See Fig. 6), is called the lead of the valve, and is given in order that the steam port may have a larger opening at the beginning of the stroke of the piston, at the time when it is most needed. It also provides a cushion against the piston as it nears the end of its stroke, which also assists in preventing the lost motion in the reciprocating parts from causing the engine to pound. It also allows of an earlier cut-off of the steam supply. The steam lap is that part of the valve which overlaps the inside edge of the outside bridge when the valve is central upon the valve-seat. It is the part of the valve marked L, and is shown by the space between lines M and M in Fig. 5.

The exhaust lap is that part of the valve that overlaps the outside edge of the inside bridge of the valve-seat when the valve is central on its seat, as shown in Fig. 5, and indicated by the space between lines P and Q. The valve is given lap for the purpose of hastening the cut-off. Also enables the engine to work steam more expansively.

WORKING STEAM EXPANSIVELY.

Working steam expansively is the process by which steam is admitted to the cylinder and cut-off (See Fig. 9), before the piston has completed its full stroke, thereby allowing the expansive force of the steam to exert its energy upon the piston from the time the cut-off takes place up to the point

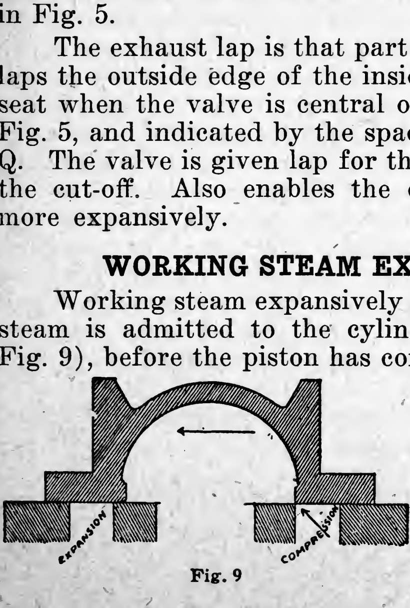


Fig. 9

where the steam is released. The distance the valve travels during the expansion of the steam equals the total of the inside and outside laps of the valve.

THE EXTENT OF LAP USUALLY ADOPTED.

In locomotive practice the extent of lap varies according to the service the engine is intended to perform. With American standard engines the lap varies from one-half an inch to one and one-fourth inches. For high speed engines the extent of lap ranges from seven-eighths to one and one-fourth inches. Freight engines commonly get five-eighths to three-fourths outside lap and from one-sixteenth to one-fourth inside lap. With a given travel, the greater the lap the longer will be the period of expansion.

INSIDE OR EXHAUST CLEARANCE.

For high speed locomotives, where there is great necessity for getting rid of the exhaust steam quickly, the valves are sometimes cut away at the edges of the cavity so that when the valve is placed in the middle of the seat (As shown in the space between lines O and P in Fig. 5) it does not entirely cover the inside of either of the steam ports. This is called inside or exhaust clearance. In many cases inside clearance has been adopted in an effort to rectify mistakes made in designing the valve motion, principally to overcome defects caused by deficiency of valve travel. The fastest locomotives in the country do not require inside clearance because their valve motion is so designed that it is not necessary. Inside clearance induces premature release and diminishes the period of expansion. Consequently inside clearance wastes steam and should be avoided as much as possible.

EFFECT OF TOO MUCH INSIDE LAP.

Engines that have too much inside lap to the valves are likely to suffer from back pressure when high

speed is attempted. The inside lap delays the release of the steam, and where the piston's velocity is high, the steam does not escape from the cylinders in time to prevent back pressure.

BACK PRESSURE IN THE CYLINDERS.

When from any cause the steam is not permitted to escape promptly and freely from the cylinders at the end of the piston's stroke, a pressure higher than that of the atmosphere remains in the cylinders, obstructing the pistons during the return stroke and causing what is known as back pressure. There is seldom trouble for want of sufficient opening to admit steam to the cylinders, for the pressure is so great that the steam rushes in through a very limited space, but when the steam has expanded two or three times its pressure is comparatively weak and it needs a wide opening to get out in the short time allowed. This is one reason why the exhaust is made larger than the admission ports. Nearly all engines with short ports suffer more or less from back pressure, but the most fruitful cause of loss of power through this source is the use of extremely contracted exhaust nozzles. Were it not for the necessity of making a strong artificial draft in the smoke stack, so that intense heat shall be created in the fire-box, quite a saving would be effected by having the exhaust opening as large as the exhaust pipe. This not being practical with locomotives, engineers should endeavor to have their nozzles as large as possible consistent with steam making. Engines with very limited eccentric throw will often cause back pressure when hooked up through the valve, not opening the port wide enough for free exhaust. Locomotives suffering from excessive back pressure are nearly always logy. The engine cannot be urged into more than moderate speed under any circumstances, and all work is done at the expense of a waste of fuel, for a serious percentage of the steam pressure on the right side of the pistons is lost by pressure on the

wrong side. Every pound of back pressure on a piston takes away a pound of useful work done by the steam on the other side.

COMPRESSION.

Steam pressure, which does not pass out of the cylinder during the time the exhaust port is open, is entrapped in the cylinder (shown in Fig. 9 and indicated by the arrows). When the valve is in this position the inside edge of the valve closes the back steam port to the exhaust. The exhaust steam which is caught in the back end of the cylinder is compressed by the piston on its return stroke. This is called the point of compression. It will be seen that both steam ports are now covered by the valve (shown in Fig. 9). The compression will continue to increase until the piston has completed its stroke. With cylinders that are not equipped with relief valves, when the compression becomes greater in the cylinder than the pressure in the steam-chest, it will force the valve off its seat and relieve the cylinder of its excessive pressure.

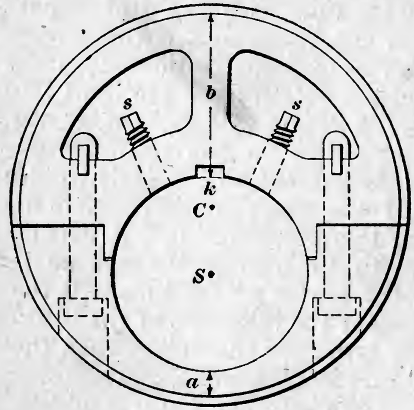
ECCENTRIC THROW AND VALVE TRAVEL.

Almost any man who is at all familiar with a locomotive knows what the term throw means when applied to eccentrics, but there are perhaps some who will be interested in an explanation on throw and its relation to the valve motion of a locomotive. The throw of an eccentric is the amount that the center of the eccentric is out of center with the driving shaft. To know how much throw an eccentric has, take a rule and measure the distance from the shaft through the large part of the eccentric; then measure through the small part, and the difference between the two is the throw of the eccentric, providing both arms of the rocker are the same length. It is, however, the practice of some to make the top arm of the rocker longer than the bottom one, in which case the full travel of

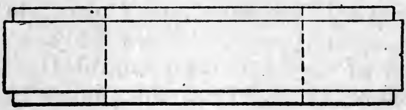
the valve will be slightly more than double the throw of the eccentric, the difference between the double throw of the eccentric and the actual travel of the valve being governed by the amount of difference in length of rocker arms. When an engine is worked at full stroke the travel of the bottom arm of the rocker just travels double the distance of the throw of the eccentric, because the forward motion eccentric rod is working in about a direct line with the link block pin, but as the engine is cut back toward the center this condition changes. The forward motion eccentric on direct motion locomotives follows the pin, and the back motion eccentric leads it. It will be seen, therefore, if the engine is standing on the dead center ahead, the throw of the forward motion eccentric would go ahead, while that of the back motion eccentric would go back. Keeping this point in mind, it will be evident that the nearer to the center the engine is cut back, the nearer to the center of the link will the link block be, and the greater the influence of the back-up eccentric to lessen the travel of the valve when the engine is being run ahead. For example, if the lever were in the six inch notch the link block pin would be pretty close to the center of the link and the influence of the back-up eccentric would be such that the steam ports, instead of being opened wide, would only be opened, say, three-eights of an inch, and would then begin to close so as to shut by the time the piston in the cylinder has traveled six inches of the stroke. The total diameter of an eccentric has nothing whatever to do with the throw. One eccentric might be twelve inches and the other twenty inches in diameter and still have the same throw. It is the difference between the center of the eccentric and that of the driving shaft that constitutes the throw in either case. For illustration, if an engine 19x24 inches had main pins four and one-half inches in diameter, and these pins were increased to six inches, it would not alter the stroke, neither would an increase in diameter of the eccentric increase its throw.

CONSTRUCTION AND DEFINITION OF AN ECCENTRIC.

A standard form of eccentric is shown with strap removed in Fig. 10, in which (a) is a side view and (b) a plan. Usually eccentrics are made of cast iron, although cast steel is now being used to some extent in their manufacture, steel being used in order that a lighter eccentric may be made without impairing its strength. Eccentrics are sometimes made in one piece, or solid, although they are generally made in two pieces to allow of their being readily attached to or removed from the axle in repairing. When made in two pieces the parts are held solidly together by means of studs and nuts, or studs with split cotters. Eccentrics are fastened to the axle in various ways; in rare instances simply by set screws, in others, as in the Figure, by a key (K) and set screws (S S), and in others by saddle keys (having teeth on their under side), held in place by means of set screws, the saddle key being used to avoid cutting keyways in the axle. The second method is the one now most generally used, however, as the key prevents the eccentric turning on the axle, and the set screws prevent motion lengthwise of the axle. The distance between the center (C)



(a)



(b)
Fig. 10

of the eccentric and the center (S) of the hole bored in it to receive the axle is called the **eccentricity** of the eccentric. In other words, considering the eccentric as a form of crank, the distance between the center (C) and (S) may be considered as the length of its crank-arm. The throw of the eccentric is twice the distance between (C) and (S), just as the throw of a crank is twice the length of its crank-arm. When an ecentric is on a driving axle its throw may be determined by measuring the least distance (a) (Fig. 10) and the greatest distance (b) between the axle and the edge of the eccentric, and subtracting the distance (a) from the distance (b). The throw, of course, will be just half this difference.

Definition.—An eccentric is a circular plate or disc which is secured to the axle in such a position that it will turn round on an axis which is not in the center of the disc. The distance from the center of the disc to the point around which it revolves is called its eccentricity. The movement of an eccentric is the same as that of a crank of the same stroke, and in locomotive construction the eccentric is preferred merely because it is more convenient for the purpose to which it is applied than a crank would be.

EFFECT OF DECREASED VALVE TRAVEL.

The effect of shortening the travel of the valve is to increase the lead, both steam and exhaust, and decrease the port opening for the admission of steam to the cylinders, which produces an earlier cut-off and increases the expansion. This causes a reduction in the port opening for the exhaust steam to escape from the cylinders and increases the compression.

ENGINES NOT HOLDING IN BACK MOTION.

A locomotive with the piston packing in bad order will not hold well in the back motion. Some kinds of piston packing do not seem to act properly when

the engine is reversed, especially at low speed, when the valve has much inside lap. There will be a vacuum in one end of the cylinder and compressed air in the other end, with the piston packing that requires pressure to expand it. The void at one end of the cylinder may neutralize the pressure at the other by drawing the air through the piston. This would be most liable to happen where the lever was kept near the center notch.

OFFSET OF THE ROCKER ARMS.

The reason for offsetting the arms of the rockers are as follows: On nearly all locomotives the center line through the driving axles is somewhat higher than the center line through the cylinders, and this being the case, in order to adjust the valve motion so that the valves will travel an equal distance each way from the center of the valve seat, with each turn of the driving wheels, the offset is made necessary in setting the valves. The valve is first placed central on the valve seat and the valve rod is adjusted for length so that when it is coupled up the top arm of the rocker will form a right angle with it, and then the bottom arm must be set back enough so that it will form a right angle with a line drawn from the center of the main axle through the center of the link block pin. The amount of offset would therefore vary from the fact that some main axle centers are nearer in line with the center of the cylinder than others, but it is a rare thing to find any locomotive where the arms are exactly in line and upon which the rocker arms are not offset.

SLIP OF THE LINK BLOCK.

The cause of the link slipping on the link-block is due to the link-block being securely fastened to the bottom of the rocker arms, therefore the block must move in an arc traversed by the rocker arm, and the action of the eccentric rods on the link forces it to

move in a vertical motion at certain parts of the stroke, which causes the link to slip on the block. When one eccentric is traveling forward and the other backward the link must move, but the block does not, hence the slip. The longer the cut-off, the greater the slip.

THE RELIEF VALVE.

A relief valve is used to prevent a vacuum forming in the steam chest and cylinders when running with steam shut off. A view of the Richardson relief valve is shown in Fig. 11, in which part of the casing is broken away to show the check valve (V). The valve is screwed into the front of the steam chest so that the chamber below the valve (V) communicates by means of the passage (X) with the steam chest. The chamber above the valve communicates with the atmosphere through the opening (A) in the valve case. When the engine is working steam the valve is held against its seat (b) by the steam pressure beneath it; but when steam is shut off the valve drops down and allows air to enter the steam chest through the opening (A), valve (V), and passage (X). The curved wings (C) are so arranged that they turn the valve slightly in closing, thus caus-

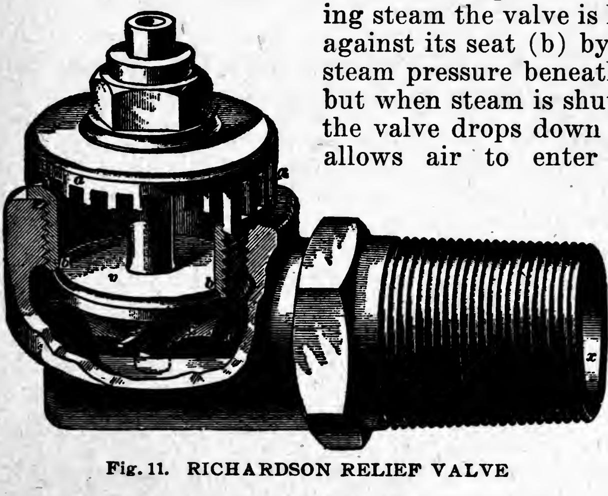


Fig. 11. RICHARDSON RELIEF VALVE

ing it to seat in a new position each time, keeping the wear uniform, the result being that the valve remains steam tight for a longer period of time than it otherwise would. Sometimes a combined pressure and vacuum relief valve is used, one of the valves preventing an excess pressure and the other preventing a vacuum from being formed in the steam chest or cylinder.

THE CENTER LINE OF MOTION.

The center line of motion on a locomotive is a line drawn from the center of the driving axle, to which the eccentrics are secured, to the center of the link block pin in the lower rocker arm.

TO INCREASE THE POWER OF AN ENGINE.

It is necesary to increase the pressure or the number of revolutions per minute, or allow a longer cutoff. Any and all of the above will increase the horse power of an engine.

WHAT HAPPENS INSIDE THE CYLINDER WHEN THE ENGINE IS REVERSED.

Suppose an engine to be running ahead and the necessity arises for stopping suddenly, and the engine is reversed, when the crank pin is on the forward center and therefore the piston is at the forward end of the cylinder, about to begin its backward stroke. The valve has the forward port open a distance equal to the amount of lead, but as the backup eccentric has control of the valve the latter is being pushed forward, and it closes the forward port just as the piston begins to move back. This shuts off all communication with the forward end of the cylinder and the receding piston creates a vacuum behind it, just as a pump plunger does under similar circumstances. At this time the back end of the cylinder is open to the exhaust and the piston pushes out the air freely to the atmosphere. By the time the piston travels about two inches the valve gets to its middle position, and im-

mediately after passing that point it opens the forward end of the cylinder to the exhaust port. When this event happens the vacuum in the forward end gets filled with hot gases that rush in from the smoke-box, and the receding piston keeps drawing air into the cylinder in this way during the remainder of the stroke, and air from that quarter seldom gets in without bringing a sprinkling of cinders. The back steam port is closed only during about two inches of the stroke while the lap of the valve is traveling over it. About the time the piston reaches four inches of its travel the back steam port is open to the steam chest, and the piston forces the air through the steam pipes into the boiler during the remainder of the stroke. The forward stroke is merely a repetition of the backward stroke. When necessary to reverse the engine it is a far better plan to hook the lever clear back than to have it a notch or two back of the center. When the link is reversed full the cylinders are merely turned into air pumps. When the links are put near the center the travel of the valve is reduced and the periods when the pistons are creating a vacuum in one end of the cylinder and compressing the air in the other are prolonged. The result is that when the exhaust is open in the first case the gases rush in violently from the smoke-box, carrying a load of cinders. In the other case the piston compresses the air in the cylinder so high that it jerks the valve away from its seat in trying to find an outlet. This causes the clattering noise in the steam chest so well known in cases where engines are run without steam while the reverse lever is near the center notch.

THE VALVES AND THEIR FUNCTIONS.

There are several different kinds of valves, but the two that are in most general use are the slide valve and the piston valve. The function of the valve is to control the admission of steam to, and the exhaust from the cylinders.

PRIMITIVE SLIDE VALVE.

In its primitive form the slide valve was made merely long enough to cover the steam ports when placed in the central position, as shown in Fig. 12. With a valve of this form the slightest movement had the effect of opening one end so that steam would be admitted to the cylinder, while the other end opened the exhaust. By such an arrangement steam was necessarily admitted to the cylinder during the whole length of the stroke, since closing at one end meant opening at the other. There were several serious objections to this system. It was very difficult to give the engine cushion enough to help the crank over the center without pounding and a small degree of lost motion was sufficient to make the steam obstruct the piston during a portion of the stroke, but the most serious drawback to the short valve, was that it permitted no advantage to be taken of the expansive powers of steam. For several years after the advent of the locomotive, the boiler pressure used seldom exceeded fifty pounds to the square inch. With this tension of steam there was little work to be got from expansion with the conditions under which locomotives were worked, but as soon as high pressure began to be introduced the loss of heat entailed by permitting the full pressure of steam to follow the piston to the end of the stroke became too great to continue without an attempted remedy. A very simple change served to accomplish this and to render the slide valve worthy of a prominent place among mechanical appliances for saving power.

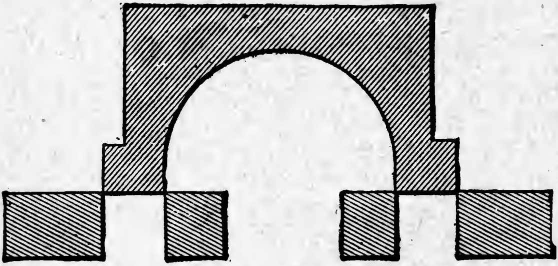


Fig. 12. COMMON SLIDE-VALVE

THE ALLEN PORTED VALVE.

The Allen ported valve, which has the supplementary port above the exhaust arch, as shown in Fig. 13, was designed to overcome the defects of the plain slide valve, with which it was found very difficult to get the full steam chest pressure at the beginning of the stroke, where it was most needed, without giving excessive lead, which would produce a premature cut-off and impair the other operations of the valve. Besides, it was found impossible to maintain a full boiler pressure during the whole period of admission when the steam was cut off short and working at high speed.

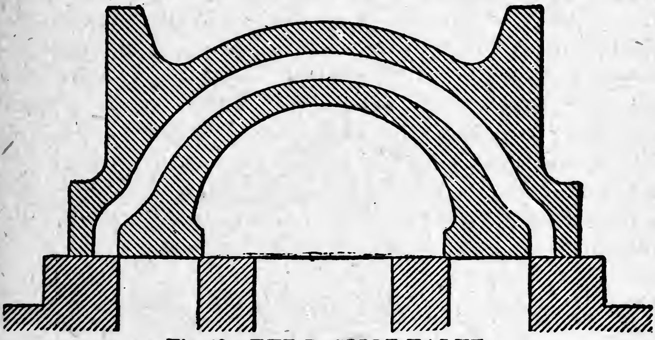


Fig. 13. THE D. SLIDE-VALVE

To obviate this evil and to lessen wire drawing, the Allen valve was made with a supplementary port by which steam is received from both sides of the valve at the same time to supply the same steam port, thereby giving twice the amount of opening a plain valve would with short cut-offs. By looking at Fig. 13, which shows the valve in its central position upon the valve seat, you will observe that both steam ports are completely closed, the same as with the plain slide valve, therefore the point of release will not be affected unless the lead is changed, when it will take place either earlier or later in the stroke. You will notice that the steam edge of the valve and the edge of the supplementary port open simultaneously, so they therefore cut off at the same time. This valve is very efficient for a high rate

of speed where the travel and the point of cut-off are very short. It maintains the initial pressure and the pressure during the whole period of admission more uniform.

BALANCED SLIDE VALVES.

For a great many years the plain slide valve answered all the purposes for locomotive service, but with larger and heavier engines and the increased steam pressure it was found almost impossible for one man to reverse an engine with such a pressure on top of the large slide valve which modern locomotives required. The object of designers was, therefore, to produce a valve that would require as little power as possible to move it, and when the balanced valve was invented the correct principle seems to have been followed, namely, the removal of the steam pressure from the back of the valve, and these valves have been universally adopted. The various forms of these valves that have been invented are too numerous to mention, but they are all constructed on the same principle, namely, that of removing the pressure off the valves.

THE ALLEN RICHARDSON BALANCED VALVE.

As shown by the accompanying illustration (Fig. 14), is a combination of the Allen ported valve and the Richardson balancing.

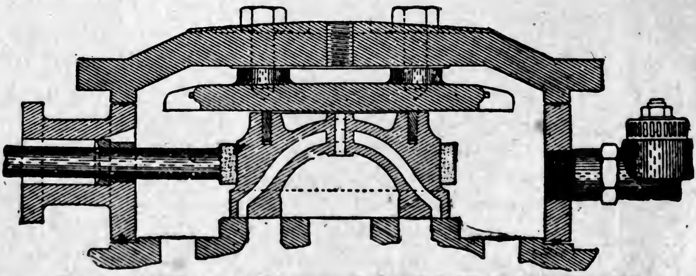


Fig. 14. THE ALLEN-RICHARDSON BALANCED VALVE

The Allen valve was not practical for locomotive service until successfully balanced by Mr. Richardson.

Owing to the shell-like construction, the excessive pressure when operating unbalanced caused a springing of the valve face and very rapid wear of valve and seat, but with this form of balance valve there are now a great many of our locomotives deriving the advantages of the supplemental Allen port.

THE AMERICAN BALANCE VALVE.

The American balance valve gives similar results to the Allen Richardson balanced valve, but uses circular tapering rings. Fig 15 shows one ring (A) removed from disk (B), which is cone-shaped and upon which the rings are fitted and are a spring within themselves. When the steam is admitted to the steam chest it exerts a pressure on the entire outside face of ring (A). This causes the ring to press more firmly against the cone and balance plate, making a steam tight joint. A balance plate is used with this kind of valve similar to the one shown in Fig. 14. The hole is drilled through the top of both these valves to allow any steam that may pass by the strips or rings to escape to the exhaust, thereby not affecting the balance feature of the valves.

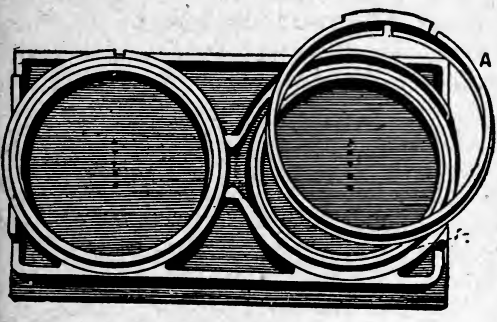


Fig. 15. Double Cone American Balance Valve

THE PISTON VALVE.

This is a slide valve of cylindrical form which has many good qualities. It derives its name from its construction and consists of two pistons (P P), connected by a stem which is generally hollow (Fig. 16).

The pistons have two or more packing rings, which form the steam and exhaust edges of the valve. Packing rings (1 and 2) form the steam edges and rings (3 and 4) the exhaust edges (See Fig. 16). It permits of a greater port area and occupies less space than the (D) valve, this form of valve being encased

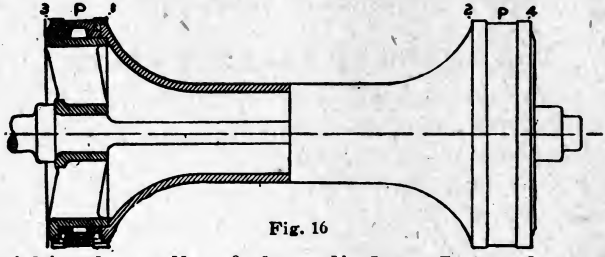


Fig. 16

in within the walls of the cylinder. It has been commonly supposed to be a perfectly balanced valve, but recent tests have proven that it is not as perfectly balanced as was generally supposed. It was found that its perfection of balance depends largely upon the middle of the rings and the steam pressure, for as long as the steam exerts a pressure under the rings, holding them against the walls of the cylinder, they create an unbalanced friction equal to the area of the rings. Of course, much depends upon the construction of the valve. Fig. 17 illustrates the piston valve bushing. The longitudinal strips or bridges are added to strengthen the bushing and to prevent the packing rings on the valve from springing past the edge of the port while traveling over them. The closer the rings fit into the grooves (See Fig. 16) the better, but it is almost impossible to get the rings steam tight without having them

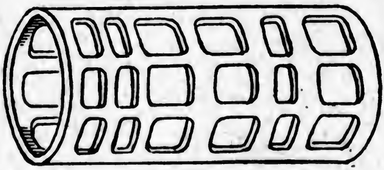


Fig. 17

stick in the grooves, and the more the sides of the rings wear, the greater will be the pressure under the rings, and therefore the greater the friction. Owing to the

construction of these valves, they being made either of one long casting or in two parts connected with a rod or tube, when the two faces are located near the ends of the cylinder, its is claimed they reduce the clearance, which is so wasteful on steam. Hence for each stroke of the piston this unoccupied space must be filled with steam, which in no way tends to improve the engine, but rather decreases the expansive force and increases the amount to be exhausted on the return stroke. While the correct principle for reducing the clearance seems to be followed in placing these valve faces near the ends of the cylinder, it should be remembered that, while the distance between the valve and the cylinder is lessened, the clearance space extends clear around this valve, and the claim of reduced clearance for these valves have frequently been overthrown by the indicator. The illustration of the piston valve that we show in Fig. 18 is the same valve that

Fig. 18. Piston Valve

is used with the Vauclaim system of compounding. It is a combination piston valve, the two ends of which control the admission and exhaust of steam to and from the high pressure cylinder, and the inner rings perform the same functions for the low pressure cylinder.

The piston valve is an old affair in locomotive practice, having lain dormant for years. One of the earliest designs of these valves was that of Mr. Thomas S. Davis, of Jersey City, in 1866. A difficulty which developed with his design, and with others at that time, was the rapid wearing away of the valve cage at the port opening, due in part to the absence of

bridge strips in the port opening. The tallow then used for valve lubrication troubled the piston valves, as it did also the plain D valve. The cause which more than any other, however, leading to the disuse of the piston valve after these early experiences, was the introduction of the balanced valve. This balance rendered the slide valve far more accetpable at the then low pressure steam standard that was used in locomotive engines, but in the meantime the piston valve has gained a position at the head of the valves used in licomotive engines.

DIFFERENT TYPES OF PISTON VALVES.

There are several kinds of piston valves used on simple engines. One is the solid valve without rings and has outside admission, as shown in Fig. 19, and

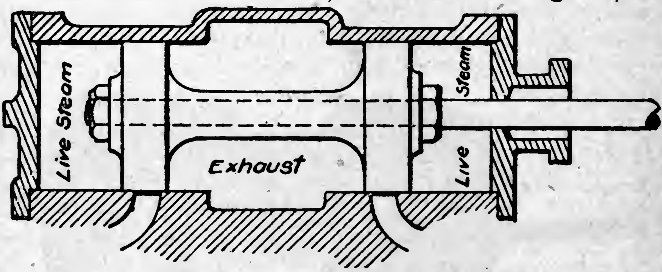


Fig. 19. Solid Piston Valve without rings, and outside admission

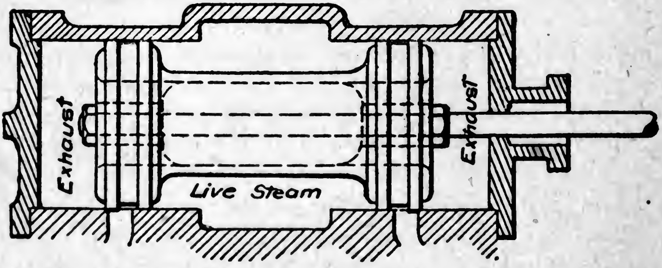


Fig. 20. Hollow Piston Valve, with rings in ends of spool, and internal admission

the other the hollow piston valve with rings in the ends of the spool, as shown in Fig. 20. It has internal admission.

Note that the internal admission valve admits steam from the inside of the spool, and the outside admission valve admits steam from the outside ends of the valve when the port is open. (See Figs. 19 and 20.)

INSIDE AND OUTSIDE ADMISSION VALVES.

A valve that is surrounded by steam, the outside edges covering the ports for admission, is known as an outside admission valve. (See Fig. 19.) The inside admission valve is usually made hollow in the center or in the form of a spool, and the inside edges of the valve uncover the ports for admission of steam; then the term inside admission valve is used. (See Fig. 20.)

DIRECT AND INDIRECT VALVE MOTION GEARS.

A direct motion valve gear as applied to a locomotive is one where the valve rod travels in the same direction as the eccentric rod, or both moving forward at the same time, and both arms of the rocker shaft turned either down or up. An indirect motion valve gear is a gear where the valve rod travels in an opposite direction from that of the eccentric rod. Both outside and inside admission valves have either motion according to the position of the eccentrics on the shaft and the type of rocker arm employed.

DIFFERENT KINDS OF VALVE GEARS.

There are several different kinds of valve gears in use on locomotives, but the ones in most general use on the different railroads throughout the United States, Canada and Old Mexico are the Allen, the Stephenson, the Walschaert and the Baker-Pilliod.

By valve gears is meant the combination of the parts that actuate and control the movement of the valves which regulate the admission of steam and its exhaust to and from the cylinders.

THE ALLEN VALVE GEAR.

The Allen gear is constructed with a straight link, and the eccentric rods are connected to this link in just opposite positions to those of the Stephenson

valve gear, the back motion eccentric rod being connected to the top link and the forward motion eccentric rod to the bottom of the link, as shown in Fig. 21.

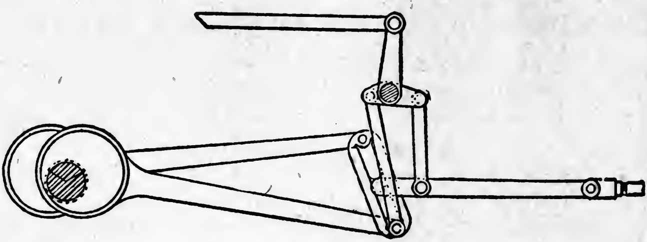


Fig. 21. Allen Valve Gear

The valve motion is reversed by moving the link block as well as the link. When the engine is in the full forward motion the links will be up and the link block at the lower end of the link.

THE STEPHENSON VALVE GEAR.

The Stephenson valve gear consists of four eccentric blocks, or cams, two for each engine, and are placed on the main axle between the frames. These cams, or blocks, are round flat discs with a round hole through them so that they will fit around the axle. The holes are to one side of the center of the block so that when the axle turns they will impart a circular or crank motion to the strap in which they work. The eccentric strap in which the eccentric block works is connected to the link by means of an eccentric rod or blade. The forward motion eccentric blade or rod is usually coupled to the top of the link and the back motion rod to the bottom. The link is a slotted bar curved to the radius of the length of the eccentric rod. A block called a link block is placed in the slot in the link, to which block a transmission bar is attached, the other end of the transmission bar being connected to the lower arm of the rocker shaft, the top arm of which is connected to the valve stem, which in turn

is attached to the valve in the steam chest by means of a valve yoke. The links are raised and lowered by means of hangers, which are in turn connected to a tumbling shaft, to which the reach rod and reverse lever are connected, which control the length of stroke and travel of the valve. (As shown in Fig. 22, which also gives the names of the different parts of the Stephenson valve gear.)

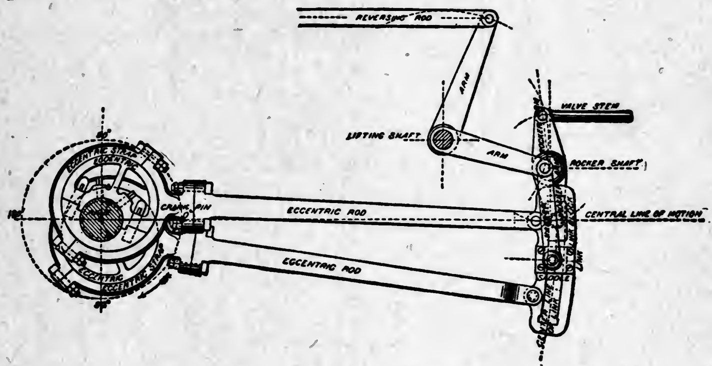


Fig. 22. Stephenson Valve Gear

The saddle pin by which the link is suspended is set out of center on the link so as to equalize the cut-off at half stroke. By the cut-off is meant the point at which the valve cuts off the admission of live steam to the cylinders at given points of the piston's stroke. With this gear the lead of the valve increases as the valve travel is shortened. This is caused by the increased angularity of the link block to the center line of motion of its controlling eccentric, and because the link block is so near to the center of the line that its movement is influenced by the opposite motion eccentric. When the link block is at either end of the link the cut-off will take place, near the end of the piston's stroke, as the link is moved so that the block will be near the center of the link. The cut-off will take place earlier in the stroke.

NAMES OF PARTS

1. Main Crank Pin
2. Eccentric Crank
3. Main Rod
4. Crosshead
5. Link
6. Eccentric Rod
7. Radius Bar
8. Valve Rod
9. Combination Lever
10. Union Link
11. Crosshead Arm
12. Valve Stem Guide
13. Reach Rod
14. Lifting Arm
15. Reverse Shaft Arm
16. Piston Rod
17. Valve

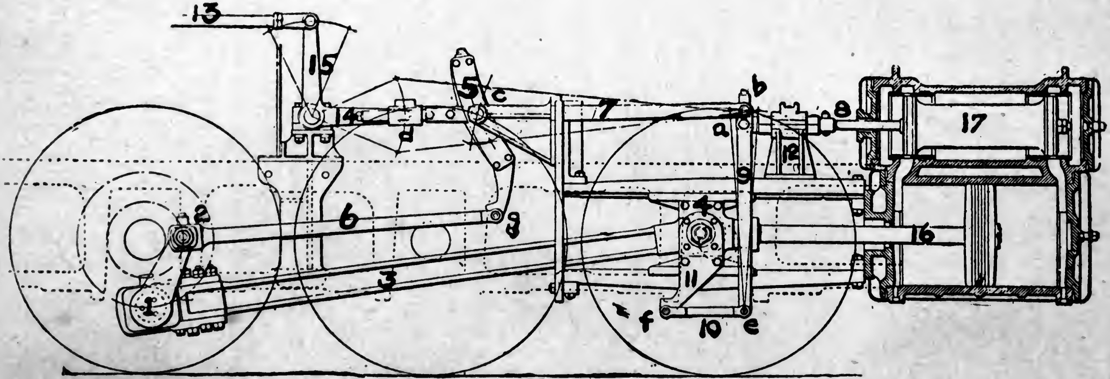


PLATE 2

The Walschaert Radical Valve Gear, with Piston Valve of inside admission, and list of names of the different parts

THE WALSCHAERT RADIAL VALVE GEAR

The Walschaert valve gear has been for many years the standard for the locomotives on the State Railways of Belgium, and is also extensively used in Germany and France. In France it has been given preference over all others for the high speed balanced compounds which have made such wonderful records. In this gear the two motions, one derived from the cross head and the other from a crank arm, or eccentric, are so combined as to produce a resultant motion similar to that obtained from the stationary link, and it is therefore classed as a radial valve gear. The revolving element is usually derived from a return crank on the main pin. With the center at right angles to the crank arm, the angular advance becomes zero, and so far as this part is concerned, the valve has neither lap nor lead. The link oscillates about a fixed axis and its arc has a radius equal to the length of the radius rod. A short arm is bolted to the cross head, and from its lower end extends a hinged connector. With the other end pinned to the combination lever, the lever so combined the crank and crosshead motions that the angular advance is restored and the valve is given a constant lap and lead. The equalization of the cut-off with the Walschaert motion is a much simpler matter and is made with greater ease than with the shifting link. This is due to the constant relation of the valve and piston motions, which are obtained by the combination lever. The chief difference between the Walschaert and the link motions is the constant lead with the former when the valve travel is changed. This is due to the fact that at the end of the stroke the crosshead alone is responsible for the position of the valve, and as the crosshead always has the same position at the end of the stroke,

the valve will also have a definite location, and the travel may be decreased, but the lead remains constant. For high-speed locomotives of the ordinary simple two-cylinder type, the constant lead may not be regarded as desirable. As early cut-offs are then used, and it is necessary to have greater pre-admission, when the cut-off is so short in order to permit the steam to enter the cylinder without excessive wire drawing. With the four-cylinder balanced compound the cut-off need not be short. The record of the indicator cards taken from a locomotive of this kind on the Northern Railway of France, as given by M. Sauvage, shows that at 77 miles per hour the cut-off in the high-pressure cylinders was 45 per cent, and in the low-pressure Cylinder 67 per cent.

So far as the distribution of steam is concerned the Walschaert valve motion will produce results as good as if not better than the link motion, and it also has mechanical advantages which recommend it. A valve gear outside of the frame is conveniently inspected and repaired, while one inside of the frame is certainly in an awkward position for either operation. With inside cylinders and crank axles there is little room for eccentrics and links, and if all this be removed it allows ample length for main pin bearings and it is then possible to have an inside bearing for the crank axle. A point worth consideration, however, in the great contrast in the weight of the moving parts and the size of the bearings. When the Walschaert outside gear is compared with similar parts of the link motion driven by eccentrics. A well-known American locomotive superintendent says: "I consider that the increased complication and weight of the valve motion are an exceedingly serious matter in giving distorted steam distribution, due to the destructive effects of the valve motion in causing wear and tear.

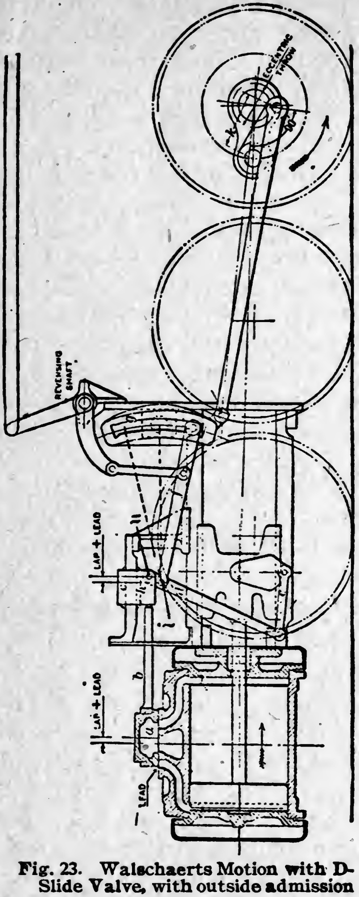


Fig. 23. Walschaerts Motion with D-Slide Valve, with outside admission

According to a paper issued a short time ago, the weights of parts of the link motion valve gear for large locomotives are as follows in pounds: Eccentric, 212; eccentric strap, 225; eccentric rod, 125; link, 148; valve rod, 66; valve yoke, 90; valve, 211. These figures indicate that the link valve gear, including the eccentrics and straps, as found on some modern locomotives, has become a very ponderous affair. Some attention has been given to the valve pattern in the effort to make it as light as possible, but the same care has not been taken with the moving details connected with it, which easily become a disturbing factor at high speeds, if made too heavy.

The principal loads which comes on the eccentrics and straps causing them to heat, is not the friction of the valve, but it is that due to the inertia of the reciprocating parts of the valve gear, whose motion is reversed twice for every revolution of the driving wheels. If we include the rocker arm, the weight, as found above, of the moving parts from valve to eccentric strap, for one cylinder is 1,052 pounds, and at high speeds the energy of this moving mass must impose a heavy load on the eccentrics. The eccentrics and straps

are the most difficult details in the locomotive machinery to keep properly lubricated, and it requires constant vigilance to prevent them from heating. When they do heat and cut, and the straps are taken down, their location inside of the frames is the most inconvenient one possible, and with the increasing weight of the machinery, this part of the locomotive repairs has become very laborous and expensive. More attention should be given to the reduction of the weight of the moving parts of the link valve gear, or some other type should be used. The Walschaert gear, located as it is outside of the frames, is easily accessible and very convenient for inspection, lubrication and repairs. The main driving bearings are too small pins with bushed bearings, and the contrast with the heavy and cumbersome eccentrics and straps which are their equivalent in a link valve gear system, is very striking. The Welscharet gear is simple and light throughout, and it has much to recommend it which would overcome the objectionable features of the shifting link motion driven by eccentrics.

FUNCTIONS OF THE DIFFERENT PARTS OF THE WALSCHAERT VALVE GEAR.

The Link—With this style of valve gear a link is used which oscillates on trunnions placed in the center of either side of a bracket which is bolted to and supports the link. The link is curved to the radius of the radius rod. With the engine on either forward or back center, the reverse lever can be moved from one end of the quadrant to the other, raising and lowering the radius rod and link block, without moving the valve or the link.

Movement of the Valve By Reverse Lever—The amount of movement imparted to the valve by the movement of the reverse lever depends on the position of the main pin. If the pin is on either dead center there will be no movement of the valve, but if on any other point the valve will be moved by any change in the position of the reverse lever.

The Combination or Lead and Lap Lever—To which the radius rod and valve stem are attached, the lower end of which is connected to the cross-head by a cross-head arm and union link, controls the movement of the valve just the amount of the lap plus the lead at each end of the valve stroke. This movement being independent of the eccentric rod or link. If the reverse lever is placed in the center of the quadrant, the link block will be in the center of the link, in this position the movement of the link by the eccentric will not transmit any motion to the radius rod or valve, but the combination lever, being attached to the cross-head, will move the valve just the amount of lap plus the lead.

Outside Admission Valve—With an outside admission valve the eccentric crank on the main pin will lead the pin in the forward motion, being set on the quarter or 90 degrees ahead of the pin.

Inside Admission Valve—With an inside admission valve the eccentric crank will follow the pin in the forward motion, as it is set on the quarter or 90 degrees behind the pin. The position of the eccentric crank in its relation to the pin is sometimes changed from the positions just described in order to overcome or equalize the angularity of the eccentric rod when the extension on the bottom of the link is shortened it carries the forward end of the eccentric rod away from the center line of motion, causing an unequal angularity of the eccentric rod, from its position on the top and bottom quarters and its connection to the link extension. Therefore in order to make the construction theoretically correct the eccentric crank would have to be moved to a position a little over 90 degrees back of the pin with an inside admission valve and moved towards the pin from its position of 90 degrees ahead of the pin with an outside admission valve.

DIRECT AND INDIRECT MOTION OF THE WALSCHAERT VALVE GEAR.

When the reverse lever is in the forward motion the link block will be below the center of the link so

that eccentric rod, radius rod and valve will move in the same general direction. This movement makes the engine direct in the forward motion. When the reverse lever is in the back motion the link block is raised above the center of the link. The eccentric rod will move the lower end of the link forward and the upper end back, drawing the radius rod and the valve back with it, and thereby causing the eccentric rod and valve to move in opposite directions. This movement makes the engine indirect in the back motion.

With an inside admission valve the radius rod is connected to the combination lever above the valve stem (As shown in plate 2), so that when the crosshead reaches the end of the stroke the valve may be drawn back the amount of the lap, plus the lead, as the motion of the cross head is always the same. Should an outside admission valve be used, the radius rod would be connected below the valve stem (As shown in Fig. 23).

Valve Stem Guide.—A valve stem guide is provided for the stem to ride in or through, and for the purpose of carrying the weight of the front end of the radius rod and combination lever, and to keep the valve stem from being drawn out of line by the weight of its connections (As shown in plate 2), thus causing unequal steam distribution.

Constant Lead.—The constant lead with the Walschaert valve gear is obtained by connecting the valve stem and radius rod to the top of the combination or lead and lap lever, and the lower end of this lever to the crosshead. The crosshead moving back and forward in the guides, transmits an angular position to the combination lever. This angularity is the greatest when the piston and crosshead are at the end of the stroke. At this point the difference between two perpendicular lines drawn through the center of the pins connecting the radius rod and valve stem to the combination lever will show the same measurement as the lap of the valve plus the lead. For this reason the lead

does not vary with the point of cut-off as it does with the Stephenson valve gear, but remains constant at all points of the stroke.

To Change the Lead—Of the Walschaert valve gear, it is necessary to either change the lap of the valve, reducing it to increase the lead, and increasing it to reduce the lead, in which case the cut-offs will occur at earlier or later periods of the stroke; or, by changing the lengths of the arms or distance between the connecting points of the combination lever, increasing the distance between the radius rod connection and the valve stem connection to the combination lever would increase the lead, and by shortening this distance would decrease the lead.

DIFFERENT KINDS OF REVERSING MECHANISM.

In Fig. 24 are shown the link and reverse shaft. In this style of gear the radius rod is directly connected to the lift shaft arm by means of a slip block, which makes a very simple arrangement.

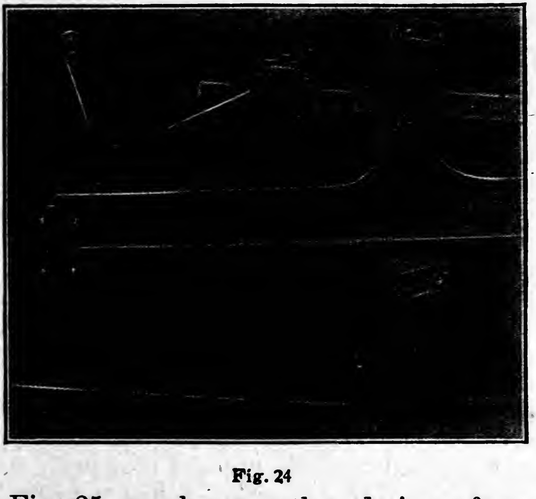


Fig. 24

In Fig. 25 we show another design of reversing mechanism. In this style of gear the backward extend-

ing arm of the lift shaft is connected to the back end of the radius rod by means of a link.

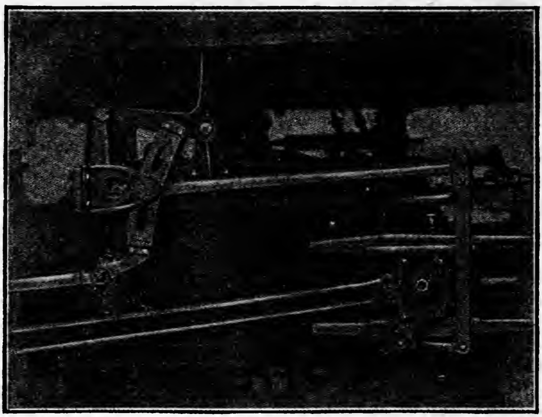


Fig. 25

VALVE SETTING WITH WALSCHAERT GEAR.

Place the engine on the forward dead center. (To find the exact center, place a mark on the crosshead and guide opposite each other, just before the crosshead reaches the end of its stroke. With a center punch put a punch mark on the main frame, just in front of the main driving wheel. Place one end of the tram in this punch mark, and with the other end of the tram make a mark on the rim of the main wheel. Then move the engine forward until the crosshead has passed the center and moved back until the marks on the crosshead and guide are again opposite each other. Then with the tram placed in the first made punch mark on the frame, make another mark on the rim of the wheel, and with a pair of dividers divide the space between the two marks on the rim of the wheel and make a punch mark. Now, with the tram in the punch mark on the frame, move the wheel until the other end of the tram will rest in the last made punch mark, and you have the dead center.) After placing the engine on its for-

ward dead center, move the reverse lever from full forward to full back position. If there is any movement of the valve forward while raising the block in the link, the eccentric rod should be lengthened. If there is any movement of the valve backward, the eccentric rod should be shortened. After the eccentric rod has been adjusted to the proper length, tram the valve travel. If it does not travel equal on both sides of the center line of the valve seat, adjust it by shortening or lengthening the valve stem. The different parts of the Walschaert valve gear are of a pre-determined size, length and movement, and under ordinary conditions are not subject to change, but when necessary the eccentric rod or valve stem can be adjusted to correct defects in link or valve travel.

THE BAKER-PILLIOD VALVE GEAR.

My readers will note in the accompanying illustrations we give of the Baker-Pilliod valve gear (Fig. 26 and 27) features which at first glance are strongly

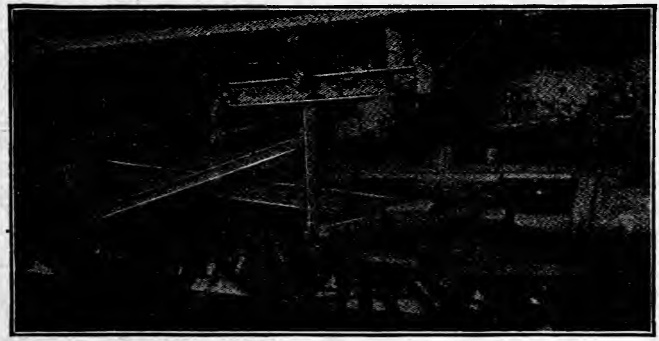


Fig. 26. Baker-Pilliod Valve Gear

suggestive of the Walschaert valve gear, but upon closer examination the differences are easily distinguishable.

The attainment of a higher efficiency from a given cylinder and valve arrangement of given dimensions must of necessity be preceded by an improved steam

distribution, causing greater mean effective pressures on the pistons and a higher range of temperature in the cylinders. This may be effected by an improvement in the method of actuating the valve. The Baker-Pilliod valve gear, it is claimed, provides uniform lead, and cut-off, late release and compression, balanced compression, and total absence of pre-admission. The motion of the valve is derived from two independent sources, as follows: From the main crank by connection to the crosshead, and from an eccentric crank opposed at right angles to the main crank. A swinging lever, or radius bar, is suspended from a reversing yoke, and is movable to any desired angle to impart the required throw and cut-off. The lever action of the eccentric arm actuates the lap and lead and maintains the lead constant. The crosshead connection takes care of the lap and lead when the radius arms and the reversing yoke are in central positions, so that in mid-gear practically all of the motion of the valve is through the crosshead connection. By moving the reverse lever forward, the angle of the reverse yoke is changed and brought into combination with the main imparting motion, toward the eccentric arm. The opening motion of the valve being accelerated for the forward motion of the locomotive in the backward motion, the reverse yoke is changed to an opposite position, while that of the valve rod remains the same as in the go-ahead motion. This reversing action requires no change in the reciprocating parts, no re-adjustment of its bearings or alignment, only a movement of the positive-connected radius arm, which, it is claimed, overcomes these objectionable points in a link-motion gear. Also that this is the only single valve gear which produces a dwell upon the opening and closing of the valve, and yet makes these events quick-acting. Comparison of a table of valve events from the Baker-Pilliod gear with similar tables from the Walschaert and Stephenson gears, taken from last year's proceedings of the Master Mechanics' Association, shows the greatest range in these events for the Baker-Pilliod valve

gear. There is a uniform lead at all points of cut-off. For the entire stroke there is a later release, and later, and more nearly balanced, compression, than in either of the other gears, and, with the exception of cut-off at 20 per cent, a total absence of pre-admission. There is also less compression and back pressure in the short cut-offs. There is no difference in the parts for inside and outside admission with this gear. The eccentric crank leads the main crank for outside admission throw. It is said high speeds have no harmful effect, nor are there any loose, sliding or lifting joints or link blocks. The weight of the gear is given as about 40 per cent of that of the Stephenson and 60 per cent of that of the Walschaert gears, and the cost of maintenance one-half that of the Stephenson. A higher mean effective pressure is claimed for this gear than for either of the others, also that only 5 per cent of the piston travel is required for full port opening. A dwell is produced upon the opening at 45 per cent cut-off, the valve closes at 70 per cent, and there is effective expansion to 95 per cent of the travel. In Fig. 27 we show this gear as applied to an outside admission valve.

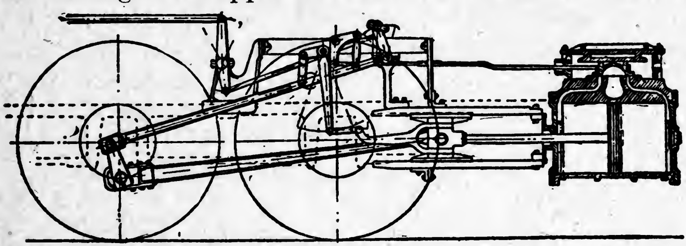


Fig. 27. Baker-Pilliod Valve Gear, outside admission

SETTING VALVE ON BAKER-PILLIOD MOTION.

In order that my readers may more clearly understand how to set the valves with the Baker-Pilliod valve gear, and in explanation of the different letters and figures used in explaining the manner in which this valve gear is adjusted, we furnish a complete drawing of the entire valve gear from the reach rod to the steam chest in Fig. 28. It is also necessary that the

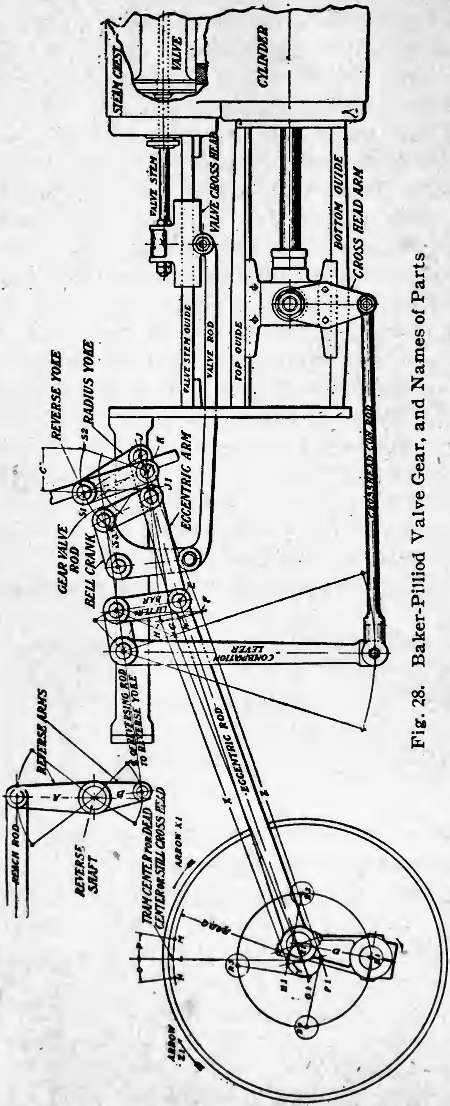


Fig. 28. Baker-Pilliod Valve Gear, and Names of Parts

trams used be in conformity with the diagram, as shown in Fig. 29. First referring to Fig. 28:

The Eccentric Crank—Should be set so as to describe a 7-inch circle on points E and R, for inside admission. For outside admission, set on G and R. The stroke, position of gear and admission of valve determines length D on diagram.

Distance from point R2 to H1 and from R4 to F1, for inside admission. For outside admission, R2 to F1 and R4 to H1. (Positions of crank R1 and R3 not used in determining length.) This gives a line Y through center of axle from points H1 and F1. The centers H1 and F1 should be an equal distance from points H and F as per lines X and Z.

Point H is position of center E (Front end of eccentric rod) when on forward dead center, and point F is the same center on back dead center for inside admission, and vice versa for outside admission. Points H and F are also on a 31-inch radius from center K. Therefore, centers J and J1 should be on point K when on dead centers. If crank is short on an inside admission engine, center J will be ahead of point K (on forward dead center), instead of being in line, and will be to rear of point K on back dead center. To find the amount short in this case, pinch wheel as indicated by arrow X1 until valve stem stands still in reversing (or changing points S1, S2 and S3). This gives point M at a distance P from center; then the amount crank is out is to 3½ inches (half the throw of crank) as P is to the radius Q. If the crank is long on inside admission engine, pinch wheel as indicated by arrow Z1 until valve is still in reversing. This gives a point N at a distance O from center. Then the amount crank is long, 15 inches to 3½ inches (half of throw) is as O is to radius Q. If crank is short on an outside admission engine, pinch wheel as indicated by arrow Z1 for still valve, the length to be found by same method. If crank is long on an outside admission engine, pinch wheel as indicated by arrow X1 for still valve, the length to be found by same method.

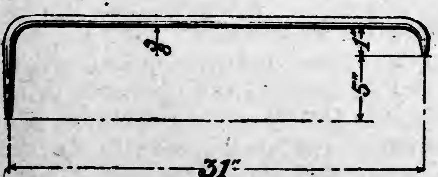


Fig. 29. Trams, to be used on points K-H and K-F. K is center of reverse yoke bearing, center for tram to be exact and on outside. F and H positions are pin centers E in lead positions.

Eccentric Rod—The centers of front end of rod, H and F, being located on an arc with a center K and a 31-inch radius (length of eccentric arm) the line W, which gives is parallel to line Y (through axle). This makes lines Z and X equal, which is the correct length of rod. Use trams shown on K and H, also on K and F.

Equalizing Valve Travel.—Reverse arms are proportioned to give travel C between points S1 and S2, also between points S1 and S2 of C is equal both forward and back of center S1, valve travel will be equal in both motions. C is to be 9 inches, which gives 6 inches valve travel with 1¼ inches lap and lead for any travel under 6-inch block quadrant. If reversing rod is long it will decrease valve travel in forward motion and increase it (the same amount as taken from forward) in back motion. Therefore, valve travel can be equalized by adjusting reach rod from lower reverse shaft arm to reverse yoke.

Leads—Is constant and can be equalized by altering length of valve stem.

Lap.—The lower arm of bell crank determines lap and lead travel, for more increase in length.

The proportions of the various parts of this gear can only be designed properly by formula plotting and on an adjustable model, and cannot be determined experimentally. Therefore, no change should be made unless the result of such change is known in advance, and if the gear is correct when engine comes out of shop, there should be no reason for changing any part of it except the length of the eccentric rod, which may be shortened slightly as the driving boxes wear on the shoes.

Note by Author.

Having given a fairly good description of the principal valve gears in use on most of the railroads in the United States, Canada and Old Mexico, I will now take up the emergency breakdowns and accidents to locomotives of different types and their remedies, that in my judgment will assist the engineer and fireman both in case of mishap or as the student for promotion. Starting first with the Baker-Pilliod gear and taking others in their turn, and I trust the information will assist my fellow enginemen to some extent in both cases.

BREAKDOWNS AND ACCIDENTS TO LOCOMOTIVES OF DIFFERENT TYPES AND THEIR QUICK REMEDIES

BAKER-PILLIOD VALVE GEAR BREAKDOWNS. BROKEN ECCENTRIC ROD OR CRANK.

In case of an eccentric rod or crank breaking, remove the broken parts, and replace pin in the lower end of the lifter bar, block the reverse yoke and radius arm together, and proceed with lap and lead travel to the valve on broken side.

BROKEN CROSSHEAD YOKE, OR UNION LINK.

In case of a crosshead yoke or union link breaking, remove the broken parts and block the combination lever, and you are ready to go with port opening travel.

BROKEN REVERSE YOKE, RADIUS ARM, LIFTER BAR, ECCENTRIC ARM, COMBINATION LEVER, LOWER REVERSE ARM.

Remove the crosshead connections and eccentric rod and secure the valve to cover the ports. If the gear valve rod or bell crank breaks, remove the broken parts that would interfere with the working of the other gear parts, secure the valve to cover the parts, and proceed without disconnecting the eccentric rod or union link. Take down the main rod and block the crosshead at the back end of the guides. With the valve motion disconnected in this way, the reverse lever is free to operate the other side, and the engine can be run in on one side. In case of an accident that requires the blocking of the valve to cover the ports, if the engine has no relief valves in the cylinder heads, it is a good practice to take down the main rod on the disabled side. But if the engine has relief valves and the main rod and piston on the disabled side are in condition to run, the main rod may be left up when the valve is secured to cover the ports. In this case re-

move the relief valve from the cylinder head to relieve compression, and to permit the cylinders to be lubricated. I have not attempted to give all the accidents that might occur on the road, as I shall next take up the breakdowns on the Walschaert valve gear and shall illustrate some of them, and as most of the breakdowns on the Baker-Pilliod gear can be handled the same as the Walschaert gear, for the want of space I put them under that head.

BREAKDOWNS OF THE WALSCHAERT VALVE GEAR.

The Walschaert gear, so far as its own parts are concerned, does not often break down or give out. The style of the valve gear has very little to do with the breaking down of the other parts of the engine. The valve itself, either a slide or piston valve, is the same with both gears. The piston and all its connections, clear to the wheel, the cylinder heads and steam chest covers, the side rods, crank pins and frame, all stand the same strains. With the Walschaert, as with the Stephenson gears, they have the same trouble and are as liable to break down, as the Walschaert gear does nothing but move the valve back and forth over the ports, to admit steam to and exhaust it from the cylinders. All we have to do with it is to take off such parts as get broken, or, in the event of breakdowns of other parts of the engine, disconnect enough of the gear so it will not move the valve. Rules for work of this kind should be broad enough to cover all cases, therefore they may call for more work in special cases than is necessary, and these are the cases where the skillful engineer shows his ability by coming in without taking down parts that are not necessary. Don't take down anything you don't have to, to make everything safe. The question today is, if you can't go yourself, let the other fellow go with as little delay as possible. Some of the moving parts, the main rod, for instance, are so heavy, that it is almost impossible for the crew with the engine and train to do anything but get it off and

leave it lying beside the track. It is also impossible for an engine crew to get the steam chest cover off of a large slide valve engine when disabled on the road, and for this reason it is the best method not to take down any more of the moving parts than necessary to get the engine in, and not risk another breakdown before getting to the repair shop. Some of the pins and connections in the Walschaert gear come out easily, as they are accessible. It is a pretty safe rule to take down first the moving parts that are easy to disconnect, if by that means you can leave up some of the parts that are hard to get down. In this article we will only take up such breakdowns as require something to be done with the Walschaert gear. At the time of the breakdown the engineer may see a shorter way of doing the work than suggested here. The Walschaert gear usually suffers more when the engine gets side-swiped, as the Stephenson gear is better protected by the wheels and frames, as the Walschaert gear is outside the wheels and frames and gets the first knocks. In such a case the moving parts that are disabled must be taken off or put in shape so they won't do any further damage, by disconnecting the eccentric rod and combination lever, as both move the valve independently of the other. If the link block hanger is down and the link block fastened in the middle of the link, the eccentric rod may be left up. It is possible to take down the back end of the eccentric rod and tie it up to some fixed part of the engine, where the rods won't strike it, and leave the front end of the rod still fast to the link. Be sure that the link is left in mid-position if the block is to be moved without moving the valve rod. The same treatment will do for the combination lever, provided that the bottom end is fastened so that it will not be struck by anything and moved. If the motion work is jammed or bent in an accident so that the block and radius bar cannot be moved up and down, disconnect the radius bar from the reverse arm. The return crank or eccentric sets out so far from the driving wheels that it can get foul of obstructions on the

right of way. If it is bent so it will not clear the rod, take it off. Most of them are made so that they come off. If the engine is moving when the return crank gets bent, it usually takes itself off the first turn. If the main pin breaks off, that means disconnect the eccentric rod from the link and take off all other broken or disabled parts. The main rod in this case is disconnected, the crosshead blocked at one end of its travel, and the combination lever does not move back and forth. Place the valve centrally over the steam ports and keep steam out of both ends of the cylinder. If there is a rocker arm between the radius bar connections and the valve rod, it may be easier to take the pin out of the rocker arm and valve stem connection. With the valve rod coupled up and the combination lever at one end of its travel, the valve should have a steam port open the amount of the lead, unless the link and its blocks are **not** in mid-position. It might be easier in this case to take down the union link and fasten the combination lever in its mid-position. This will place the valve centrally over the ports if the radius bar is also in mid-position. Some ten-wheel and consolidation engines have the combination lever back of the guides next the forward driver. In this case, when disconnecting a forward side rod or blocking a crosshead, be sure that the crank pin will clear everything when the engine is moving. A broken crosshead needs the same work done as for a broken crank pin, as far as the valve gear and main rod are concerned, but you do not have to take down the side rods. It is a good plan to have a block all ready cut and fitted to the opening next the link to hold the link block and radius bar in mid-position.

At first thought it would seem that the link slot is the only place for a block to hold the radius bar in mid-position, but there are other places outside the link where the bar can be blocked or fastened to hold it central. With the link fastened in its central position, the block can be anywhere in the link slot without moving the valve. When the reverse lever or any

of its connections give out, treat the trouble the same as with the Stephenson gear, and the same for a broken valve or valve stem. With some breakdowns it is not necessary to take down the main rod. To lubricate the moving piston, place the valve so a very little steam will pass into the cylinder and have the cylinder cock open at that end. Leave the lubricator feeding on that side; the oil will work down with the steam. If the engine stops on the center on the good side, shut the cylinder cock, and as soon as the steam builds up a pressure against the piston on the disabled side it will move the good engine off the center, then open the cylinder cock again and go on. It is always a good plan to look the gear all over when you first get the engine and study out where it comes apart easiest. Then in case of a breakdown you won't make any wrong moves. I will now take the most common breakdowns the Walschaert valve gear is heir to and illustrate them in as plain a way as possible, and I trust they may be of some aid in case of trouble to my readers. Many of the above pointers will apply to the Baker-Pilliod gear as well as to the Walschaert.

COVERING THE PORTS FOR BROKEN MAIN ROD, BENT PISTON ROD, OR KNOCKED-OUT CYLINDER HEAD.

In all cases of breakdowns with this gear, where it is necessary to cover the steam ports, if the engine has no relief valves in the cylinder heads to remove, it is a good practice to take down the main rod on the disabled side. As, for example, the main rod was broken, or the piston rod bent, or a cylinder head knocked out. In any of these cases, if the valve has inside admission, and there are no relief valves in the cylinder heads, the engine can be disconnected (as shown in Fig. 30). Disconnect the front end of the radius rod from the combination or lead and lap lever, and suspend it clear of the latter by means of a wire or chain from some convenient support. Secure the valve to cover the ports. This can be done by means

of the set screw usually provided in the valve stem guide for this purpose, but if there is no such set screw, the valve stem may be blocked. Take down the main rod and block the crosshead at the back end of the guids (as shown in Fig. 30). With the valve motion disconnected in this way, the reverse lever is free to operate the other side and the engine can be run in on one side.

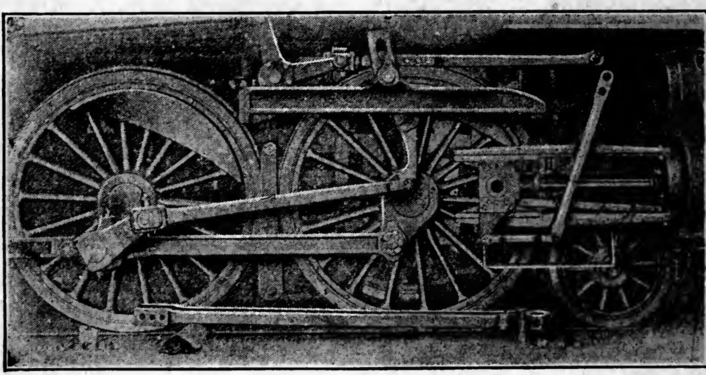


Fig. 30

FOR BROKEN CROSSHEAD ARM, COMBINATION LEVER OR UNION LINK, WITH OUTSIDE ADMISSION VALVES.

In case of any of the above parts becoming broken, the engine can be blocked in the same way as shown in Fig. 30, except that, of course, any of the broken parts that would interfere in any way with the running of the engine must be removed. If the valves have outside admission and there are no relief valves in the cylinder heads, in cases where it is necessary to secure the valve to cover the ports, such as have been mentioned, the engine can be disconnected, as illustrated in Fig. 31. Disconnect the radius rod from the combination lever and take down the latter, as if left up the front end of the radius rod would strike the lever as it moves

back and forth to the motion of the link. Suspend the front end of the radius rod from the valve stem guide, using for this purpose a wire or chain. (The fire door chain if no other is handy.) Secure the valve to cover the ports, and take down main rod and block crosshead at back end of guide.

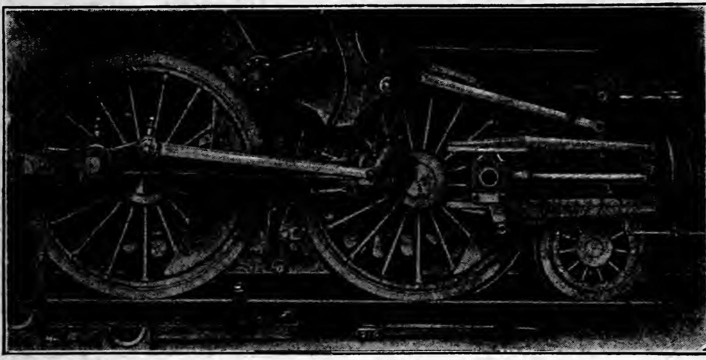


Fig. 31

If the engine has cylinder relief valves and the main rod and piston are in condition to run on the disabled side, the main rod need not be taken down, when the valve is secured to cover the ports, but in that case remove the relief valve from the cylinder head to relieve compression, and to allow of lubricating the cylinder.

BROKEN COMBINATION LEVER, UNION LINK OR CROSSHEAD ARM, WITH INSIDE ADMISSION VALVE.

In case of any of the above named parts breaking, with an inside admission valve and relief valves in the cylinder heads, they can be blocked, as illustrated in Fig. 32. Disconnect the radius rod from the combination lever and fasten it clear of the latter, as shown in Fig. 32. Secure the valve to cover the ports. Fasten

the lower end of combination lever to the cylinder cocks with a wire or rope. Take out relief valves as recommended above, and the engine can then go in on one side.

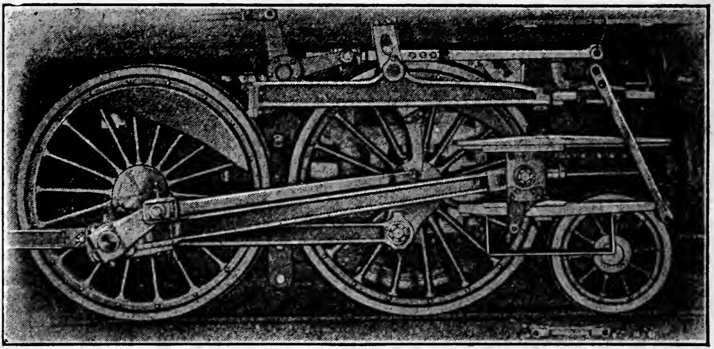


Fig. 32

BROKEN ECCENTRIC CRANK, ECCENTRIC ROD, FOOT OF LINK OR LINK TRUNNION.

In case of a broken eccentric crank, eccentric rod, or foot of link is broken, or one of the link trunnions is twisted off, the other trunnion still holding the link in position, take down the eccentric rod, disconnect the back end of the radius rod from the lift shaft arm and secure the link block in the center of the link. With the motion disconnected and blocked in this way, the valve on the disabled side receives a travel from the combination lever equal to twice the amount of the lap plus the lead, which gives a port opening equal to the amount of lead. This permits of leaving the main rod up and going in with both sides, and the cylinder can be lubricated, and though the cut-off will be very short on the disabled side, what steam is admitted will do some work and the engine can be reversed. Fig. 33 illustrates an engine with the gear disconnected and blocked as above. In the illustra-

tion the radius rod is connected to the lift shaft arm by means of a radius rod hanger so that it can be readily disconnected by taking out the pin connecting the radius rod hanger and the lift shaft arm. The link

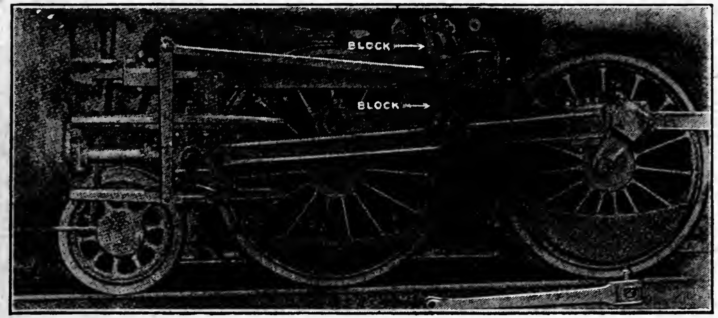


Fig. 33

block is fastened in the center of the link by means of two blocks (as shown in Fig. 33), one above and one below the block and wedged in position.

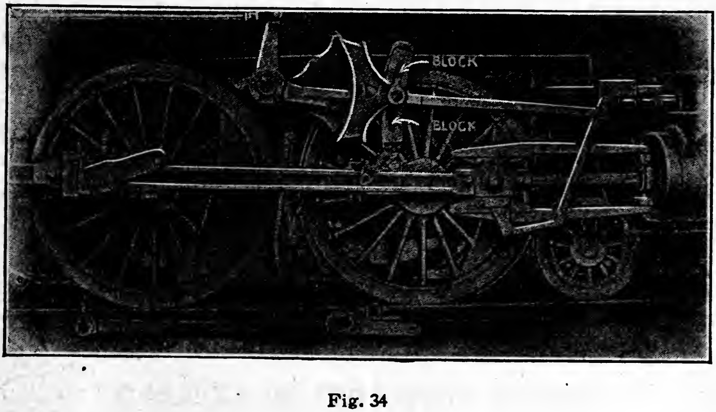


Fig. 34

When the link block is secured in the center of the link, great care must be taken in stopping, that the main pin on the disabled side does not stop on either

quarter, for in this case the combination lever would be in a perpendicular position, as shown in Fig. 33, and the valve would be central on its seat, and as the pin on the good side would be on its dead center, the engine would not move.

In some designs of the Walsehaert gear, the radius rod is connected directly to the lift shaft arm, by means of a slip block or crosshead. In such cases it is common practice to make the lift shaft arm in two pieces, so that the radius rod may be easily disconnected from it, as illustrated in Fig. 34. Remove the outer section of the lift shaft arm, take off the cap of the slip block, lift out the end of the radius rod and remove the slip block. The parts necessary to take down are shown in Fig. 34. The block is secured in the center of the link, as shown in Figs. 33 and 34.

BROKEN RADIUS ROD.

With the radius rod broken, the engine would be disabled on that side, so just remove the broken parts, block the valve to cover the ports and arrange to lubricate the cylinder, either by removing the indicator plugs, if the engine has them, or, if not, by slacking off on the front cylinder head, and you are ready to go.

BROKEN SIDE RODS.

In a breakdown of this kind treat it exactly as you would with a Stephenson link motion engine. That is, take down the corresponding section of rods on the opposite side, and proceed.

BROKEN BACK CYLINDER HEAD.

Handle the same as for bent piston rod.

BROKEN FRONT CYLINDER HEAD.

Disconnect the radius rod and center the valve (both in the instructed manner), except that in this case it is only necessary to remove one cylinder cock,

the back one, or, if the engine has indicator plugs screwed into the cylinder, remove the back one and you are ready to go.

BROKEN SUSPENSION BAR.

If broken where connected to an extension of the radius rod, beyond or back of the link, or if the extension of the radius rod should break, in either case put the reverse lever in a notch of the quadrant that will give the valve an average cut-off, or in which it may be continuously worked and handle your train, either forward or back gear, according to the way in which the engine is to run. Then raise the radius rod with the broken piece or hanger until the link block is at the same height in the link as the one on the opposite side of the engine, and insert a piece of wood in the link slot under the link block to hold it up, and another piece above the block to keep it from slipping up. Remove the broken parts and proceed. Remember not to move the reverse lever, or try to reverse the engine.

BROKEN VALVE STEM.

In case of a broken valve stem, disconnect the front end of the radius rod, tying it up to clear, block the valve to cover the ports, and make the usual provision for oiling the cylinder. Unless a good light chain is handy with which to suspend the front end of the radius rod, it is advisable to disconnect the lifting arm also and block the back end of the radius rod in center of the link.

HOW TO LOCATE BLOWS AND POUNDS IN A LOCOMOTIVE

I will first call attention to a few of the parts where blows occur most frequently, and describe their various sounds, and the action of blows under different circumstances, which may assist in determining the location of a blow before a test is made. I will then explain the correct way to test the engine and determine the location of a blow.

A blow may be in the cylinder packing rings, the valve seat, the gibs, rings or rider of a balanced valve, or it may be in the steam pipes or niggerhead, or it may be a crack or a hole in the steam ports. If it is an intermittent or recurring blow, a round, roaring, rumbling sound, like Whor-r-r-r. you may depend upon it being in the cylinders, and you can usually locate in which cylinder it is by watching the crank pins on a slow pull, as it will usually be worse when the piston is in the center of its stroke. If it is a continuous, sharp, shrill sound, like Whis-s-s-s, it is generally in the valve seat, but a valve sometimes blows intermittently when the valve cocks at one end. If it is a strong, continuous blow and you have balanced valves, it is possible one of your valve strips, valve springs, rings or rider, is broken, but if your engine has a plain slide valve, reverse the engine two or three times real quick, as it may be only a cocked valve. If it will not reseat in this way, remove the oil plug from the steam chest cover and drive it down. (Remember, balanced valves do not cock.) It may prove to be a sand hole in the valve or between the ports.

A steam chest blow is easily distinguished from a steam pipe blow because it will blow straight out the stack and makes a clear whistling sound, while a steam pipe blow expends its force in the front end and makes very little if any noise when going out the stack. A steam pipe blow, if very bad, will affect the draft of the fire, and when the fire door is open it sounds like

a leaky stay bolt. A good indication of a steam pipe leak is the appearance of water in the steam pipe end.

If you have lost one exhaust it may be a slipped eccentric, as that will cause the valves to sound out of square. A valve yoke, cracked or broken on one side only, will cause one exhaust to sound out of square, while the other three are perfect. When the valve stem breaks off it will usually cause a tremendous blow, which will continue as long as the throttle remains open, but if you have a tremendous blow at one point only and have lost one exhaust, and the three remaining exhausts are perfect, it may be a broken bridge. Notice the cylinder cocks before you stop and see if steam appears at only one cock when the piston is at one end of the cylinder, and at both cocks when at the other end. If so it is a good indication of a broken bridge, but examine your eccentrics as soon as you stop. When an engine has a bad blow when in full gear, which disappears when hooked up a few notches, it indicates that the valve travels too far and opens the exhaust port to direct steam chest pressure. This is sometimes caused by the top arm of the tumbling shaft working loose. Perhaps the key is lost. When the exhaust nozzle is gummed up it produces a sort of asthmatic wheeze or whistle, which is often mistaken for a blow. When two exhausts are heavy and two are very light, you may have blown out a nozzle tip, providing you have double nozzles. When the dry pipe leaks the engine will work water through the cylinders, and when standing in the roundhouse it may be discovered by a constant leak at the cylinder cocks. A leak at the bottom of the exhaust pipe will not cause a blow, but will affect the exhaust.

TESTING FOR BLOWS.

From the description I have given of the different blows, you can usually determine about where the blow may be found, and proceed to test that particular part without giving the engine such a severe test as I have

outlined. As this chapter necessarily covers all kinds of blows, we will first test the steam chest and then the cylinder. It is an easy matter to determine in which cylinder a blow is in, but it is often very difficult to locate which steam chest, so follow these instructions closely. Place each rocker arm in a vertical position, alternately block the wheels, open the cylinder cocks and give the engine a little steam. If no steam appears at either cock you may depend that the valve seats are tight. If your engine has balanced valves, test the valve strips, rings or riders. A blow of this kind is some times very difficult to locate, but it can be done. If your engine has drain cocks screwed into the exhaust port, go under the cylinder and open the cocks and have the fireman give her a little steam. If steam appears at either cock, that is the side your blow is on. Another way is to open the front end, if you have a double nozzle and you can see which side blows. This kind of a blow can sometimes be located by the increased friction, which will cause the valve stem to jerk when in motion, or it may be discovered by placing the crank pins on center alternately and handling the reverse lever under steam pressure. The blow will be on the side that handles the hardest, while the pin is on the quarter (not the center). Hoping these suggestions will assist you, we will return to the valve seat.

Now if steam does appear at both cylinder cocks on one side, while the steam ports are covered, it is evident that the valve seat on that side leaks, providing the opposite side is tight. The leak may be in the valve seat or beneath the false seat, or if the valve has inside clearance, it may be a flaw in the valve. If steam appears at only one cylinder cock on only one side of the engine while the ports are covered; it may be a sand hole between the supply port and the steam port, but is more probably a false seat loose on one side. If steam appears at the forward cylinder cock, the forward end of the false seat is loose, and if

at the back cock, the back end. Now if steam appears at both cylinder cocks on both sides, it is evident that the valves on both sides blow. We will now proceed to test the cylinder packing. Placing each main pin on either quarter alternately and with the reverse lever in the forward notch, give the engine a little steam. If steam escapes at only one cylinder cock the cylinder packing on that side is all right, but before leaving it place the reverse lever in the back motion notch and try it there. Now if steam appears at both cocks when one port is open, and at only one cock when the other is open, it indicates a broken bridge, although a broken valve strip or ring might cause this, or a sand hole in the bridge below the valve seat. Which particular bridge is broken may be determined by noticing which port is open. When it shows steam at both cylinder cocks, if the forward port is open, then it is the forward bridge, and vice versa. A broken bridge can usually be determined from a crack or a sand hole by a tremendous blow. If steam appears in great volume at both cocks when the lever is in both motions, it is then impossible to say whether it is a broken valve seat or broken cylinder packing rings, so have the cylinder head removed first. If it is all right, then you know it is the valve seat. A broken cylinder packing ring can usually be distinguished from one that simply leaks by the volume of the blow A packing ring that leaks will also show steam at both cocks when in both motions, but will not be such a heavy blow as a broken ring will produce. Most every engineer has had some experience with packing rings that simply blow and can distinguish it from anything extraordinary, such as a broken bridge.

TESTING FOR BLOW IN PISTON VALVE.

To test for a blow through the rings of a piston valve, place the valve in mid-position, as shown in

Fig. 35, so as to cover the steam passage leading to the two ends of the cylinder. With this piston valve steam is admitted to the chamber S and the cavity C of the valve is filled with steam as long as the throttle is open. Consequently, if the packing rings are broken or badly worn, or if the bush is badly worn, steam will blow between the rings and the bush into the exhaust passage E and then out, as shown by the arrows, thus causing a blow. Also steam will pass the packing rings into the steam passages A and B, thence into the two ends of the cylinder, and will show at cylinder cocks when open. If the rings in one end, say the front end, of the valve give out, it will cause a continuous blow through the exhaust, the sound of which as the engine is running along will, of course, be loudest between the regular exhausts of the engine. A loose valve bushing also will allow steam to blow between the cylinder casting and the bush, and thence out through the exhaust, causing a continuous blow that will be difficult to distinguish from a bad valve blow, broken packing ring or bridge.

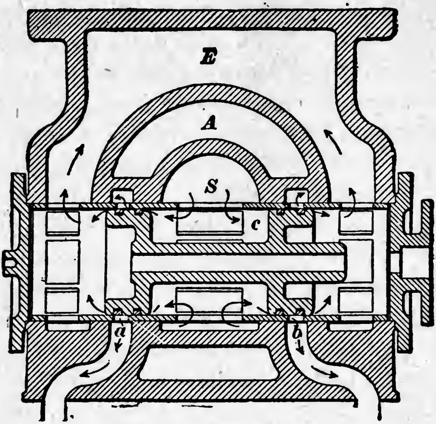


Fig. 35. Piston Valve

When you raise the steam chest cover, first examine the rings or valve strips and springs. See that the valve strips do not fit too tight on the ends, for the long strips expand one-thirty-second of an inch more than the valve and often cramp the short strips. Next examine the valve seat and face, then the bottom joint of a false seat and the pressure plate and face off

all joints that need trueing up. Now examine the valve carefully for sand holes. If you cannot locate the blow elsewhere, then fill the supply ports with water (one at a time). Open the cylinder cocks and see if it leaks water. If it does there is certainly a sand hole or crack. If not, then fill the cylinder and steam ports and see if it leaks into the exhaust cavity. Open the drain cock at bottom of the exhaust cavity.

POUNDS IN A SIMPLE ENGINE.

An experienced engineer, who is familiar with the various sounds produced by a locomotive, can very often locate a pound by its particular sound. One of the most deceiving pounds to find on a locomotive is a loose piston head (or spider). Their knocks have deceived many old runners. They usually come suddenly and sound as if there was an inch of lost motion somewhere, when in fact it may not be more than the thickness of tissue paper. Such a knock is often mistaken for a loose wedge, driving brass, crosshead or main rod brasses. The noise is similar to that made by a crosshead being loose on the piston rod and will occur when passing both centers. If a serious pound or knock is neglected, it may be the cause of disabling the engine. For this reason it should be located and reported without any delay, and relieve the engineer of further responsibility. I will now give you the different methods used to find the different pounds a locomotive is heir to.

METHOD OF LOCATING POUNDS.

When you have determined which side of the engine the pound is on, the best way to locate it is to place the crank pin on that side on the top quarter, block the wheels and have the fireman give the engine a little steam and reverse the engine a few times, while you watch all points on that side where there is liable to be a pound. The reason the pin is placed on the

top quarter, when you wish to find a pound, is because the crank pin is free to move at that point. If the pin was downward the weight of the engine would have to be moved before you could find a thump in a driving box or frame. If the pin was on either of the centers you could get the steam in only one end of the cylinder when the reverse lever was moved. Knocking or pounding may be caused by an insufficient oiling of the cylinder, or lost motion in any of the reciprocating parts, such as the main rod brasses, loose crosshead pin, or loose crank pin, or a bad fit between piston rod and crosshead or piston. If a piston strikes the cylinder head it will cause a knock, brasses or wedges, loose knuckle pin or bushing, or loose middle connection brasses, wedge down, so when wedges are struck they will cause a thumping sound, a broken engine frame, or loose cylinder, or loose deck, will also cause a bad pound. Very loose pedestal braces on light frames will sometimes cause a pound. Imperfect fitting up of sleeves and wedges, while undergoing repairs, is also a cause of many pounds. Another cause of pounding in the driving boxes is loose oil cellars, loose driving brasses, either circle or gib brasses, will cause a pound. Square bottom spring bands, or poorly fitted spring saddles, or any interference with a free movement of the equalizer, will also cause a knocking sound. See that the springs do not rub the boiler or the saddle strike the engine frame. Pounds are also caused by water in the cylinders. Cylinders of unequal size in a single expansion engine will cause unequal stresses and produce a jerking motion. Excessive back pressure will also cause a pound in the cylinders. Imperfectly balanced driving wheels will create a jerking of the engine. Too great or too small a compression will cause a jerk when passing over the center. Lost motion in the valve gear will often cause the reverse lever to rattle. Badly distorted valves cause an unequal distribution of steam, often creates a jerking sensation when hooked up near the center notch. A

loose follower bolt will usually cause a knocking in the cylinder when steam is shut off, and packing springs sometimes cause a sort of clicking sound.

TO PREVENT BREAKDOWNS AND ACCIDENTS.

Breakdowns and accidents can, to a certain extent, be prevented by a thorough and careful inspection of the engine before leaving the enginehouse, also when oiling it is a good plan to get in the habit of noticing the different parts, with their nuts and bolts that would cause trouble should they work loose or break. An engineer should set up the wedges or see that they are properly set up by the roundhouse man, see that all nuts and bolts are tight, also that all bearings are properly oiled and packed, and all oil holes open for lubrication. Key up all rod brasses, keep the headlight clean, put in any needed lubricator or water glasses, and all boiler attachments in the cab well packed and free from leaks, and do such work on the road as will assist to make a successful trip, and on arrival at his terminal report all necessary repairs which are needed on the engine and tender and their appliances.

LOCOMOTIVE BRAKEDOWNS AND QUICK REMEDIES

In case of an accident we presume the engineer will first comply with his book of rules regarding signals, flagmen, etc., and will not neglect his boiler or fire-box sheets. While working on a disabled engine, if the engine is in the ditch or the crown sheet not properly protected, kill the fire immediately. If you cannot secure water or snow or anything else, gravel will put the fire out. All well equipped engines should be supplied with a sufficient number of jacks, hand tools, wrenches, blocks, etc., to be used in case of an accident, and every prudent engineer will see that his engine is supplied with such things before starting out on the road.

DISCONNECTING ENGINES AND LEAVING UP MAIN RODS IN CASE OF ACCIDENTS.

On many of the large railway systems the practice of taking down the main rod for a great many mishaps that it used to be taken down for, is being done away with. In many cases the cause for this is the heavy power now in use on most roads, the rods being so heavy that it is almost impossible for the engine crew to handle them, besides it takes time (and time is money nowadays). Another cause is that it takes more time to get the engine ready for service again when rods and other parts are taken off that could have been left up as well as not. Besides, the seeming reason for taking down main rods in many cases has been done away with by the use of the indicator plugs screwed into the cylinders of most makes of modern locomotives, as the greatest objections in days gone by seemed to be a fear of cutting the cylinders for want of lubrication.

I think, myself, in a great many cases where rods were taken down, they might have been left up. For if your engine has no indicator plugs screwed into the

cylinders to oil through, there are several ways oil can be gotten into a cylinder so as to leave the rod up on the disabled side. For instance, the valve can be blocked just a little open, or the cylinder head removed, or by taking out a cylinder cock, oil can be sucked up into the cylinder in sufficient quantities to prevent cutting. So if you are working for officials, or on a road where they want them taken down, you had better do it. But if you are on a road where the management allows the main rods left up, why, I say leave them up by all means. So in referring to the contents of this book on breakdowns, where it says take down rods in case of mishaps, you **can cut that part out,** providing your judgment and management allow of leaving them up.

DISCONNECTING ONE SIDE.

Remove the main rod on the disabled side and place the liners, bolts and brasses back in the strap just as you found them. Secure the crosshead near the back end of the guides with a crosshead clamp, if you have one. If not, then use hard wooden blocks, securing the blocks with bell cord or wire or any other available thing so they cannot work out. Don't move the crosshead clear back to the striking point as the cylinder packing rings may get down into the port or counterbore. Disconnect the valve rod and set the valve central on its seat, and secure the valve stem with a valve stem clamp, if you have one. If not, you can clamp the valve stem by tightening the gland on one side. Most engines that use the metallic packing are supplied with a valve stem clamp, made to hold the valve central upon its seat. If you have none the valve can easily be set to cover the ports by pluming the rocker arm before disconnecting the valve stem, or by opening the cylinder cocks and giving the engine a very little steam, then adjust the valve stem until steam is shut off from both cylinder cocks. Do not remove the eccentric straps or blades, or side rods unless it is necessary. Whenever the eccentric straps are removed on one side, the top of the link should be tied to

the short arm of the tumbling shaft to keep it from tipping over, which would prevent reversing the engine. If it is necessary to take one side rod down **always** remove the one directly opposite to it. If this cannot be done, then remove all side rods. Do not remove the eccentric blades, leaving the strap on the eccentric unless they will whirl and clear everything in all positions, otherwise they might punch a hole in the fire-box. If the side rods have been removed from a ten-wheel engine or pony engine see that the forward crank pins will clear the cross-head in all positions, if not **take no chances**, but disconnect both sides blocking both cross-heads clear forward, or wherever they will clear the crank pins and have the engine towed in.

DISCONNECTING BOTH SIDES.

This implies that the engine is dead and must be towed in. Remove both main rods and both valve rods, but it will not be necessary to block either if the crank pins clear the cross-heads; do not remove the side rods or eccentric straps unless it is necessary. When it is necessary be sure to take the precaution previously explained. In freezing weather if the fire is drawn, all water should be drained out of injectors and branch pipes. If there are no frost plugs, slack the joints and let the water out. If there is danger of its freezing in the boiler let it out of both boiler and tank. See that oil cups are well filled before starting. Most roads are very strict regarding the speed of dead engines as the engine is not then counterbalanced perfectly and is therefore very injurious to the track. Some of the best roads limit the speed of all heavy engines that are disconnected on one or both sides or which have the side rods removed, or dead engines hauled in a train to twenty miles an hour.

BROKEN FRONT CYLINDER HEAD.

If a front cylinder-head is broken and the piston is all O. K. clamp the valve to cover ports, disconnect the valve stem and proceed with one side. With the

light engine, as it is not considered practical to try to take part of a train with one of the modern engines on one side, on account of the trouble of getting it off the center in case it should stop on the dead point. If the cylinder cannot be oiled through the broken head, keep the lubricator feeding and move the valve to one side occasionally uncovering the port to the cylinder. The oil which has collected in the steam chest will then pass through the port and lubricate the cylinder then center the valve and clamp the valve-stem again and proceed. Keep the cylinder-cocks open on the disabled side. Ordinarily an engine will run 25 to 30 miles without oil or cutting.

BROKEN BACK CYLINDER HEAD.

In case of a broken back cylinder-head, center the valve to cover the ports, disconnect and clamp the valve stem. Take down the main rod, block the cross-head at back end of guides, and proceed on one side with cylinder cocks open on disabled side.

BOTH FORWARD CYLINDER HEADS BROKEN.

This is a subject that has received considerable attention from railroad men. It is a sort of a catch question propounded to test a man's knowledge of valve motion. For it is very seldom such an accident occurs. When it does happen ninety-nine engineers out of a hundred either telegraph for new cylinder heads or have their engine towed in. However, if both pistons are all right and both forward steam ports are properly blocked, the engine could handle itself in this condition, but such a method is impracticable on account of the shape of the ports and the improbability of getting the port securely blocked without interfering with the movement of the valve. Fight here it may be well to state that it is the steam port which should be blocked, and not the supply port.

BROKEN VALVE, VALVE STEM OR YOKE TESTING FOR.

Should a valve, valve stem or yoke break inside of the steam chest, the breakage can be located by putting the engine at the half stroke, plumbing the rocker arm, open the cylinder cocks and admit a little steam to the chest. Now if steam blows out the stack at any position of the reverse lever, it indicates that the valve is broken in such a way that steam gets into the exhaust cavity. If the steam shows at one cylinder cock only, and can be shut off from that end of the cylinder by moving the reverse lever, it indicates that part of the valve is broken off. If while moving the lever from full forward to back gear, the steam steadily flows from one cylinder cock, it indicates that the stem or yoke is broken, and should the steam flow alternately from both cocks or can be shut off from the cylinder entirely, it will be a good plan to test the opposite side in the same manner.

TO BLOCK FOR A BROKEN VALVE.

Should the valve be broken through into the exhaust cavity, the steam chest cover must be removed and the supply ports to the chest blocked. Build up on these blocks as shown in (Fig. 36), and hold in place by fastening down the steam-chest cover. Take down

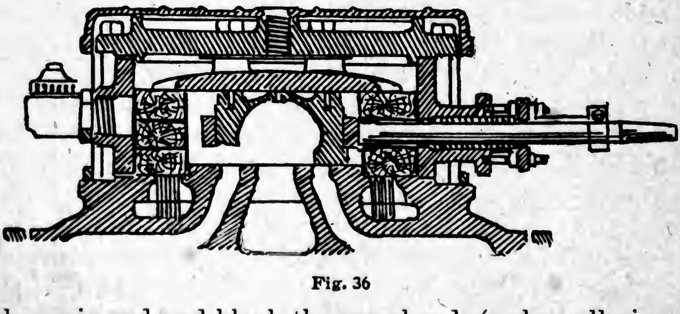


Fig. 36

the main rod and block the crosshead, (unless all pieces of the broken valve can be found and removed) as some

of the pieces might get into the cylinder and do more damage if the main rod is left up.

BROKEN VALVE STEM OR YOKE.

Should the valve stem or yoke break on an engine where the relief is on the front end of the steam-chest. Place the valve central, disconnect the valve stem, take out the relief valve and push the valve back against the stem and insert suitable blocking against the valve on the opposite side. Secure blocking by screwing relief valve back into chest as shown in Fig. 37.

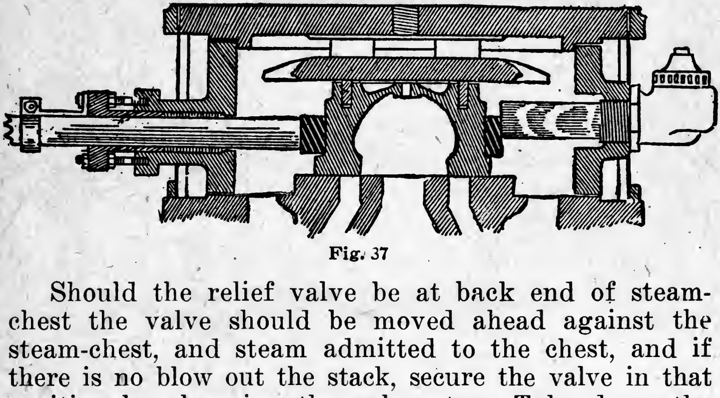


Fig. 37

Should the relief valve be at back end of steam-chest the valve should be moved ahead against the steam-chest, and steam admitted to the chest, and if there is no blow out the stack, secure the valve in that position by clamping the valve stem. Take down the main rod and block the crosshead at forward end of guide. Remove front cylinder cock, or block it open as shown in Fig. 38.

If steam blows out the stack with the valve at the front of the chest, you will have to take up the chest cover and block the valve central on its seat and secure it there with the valve stem and a block of wood against the valve and front end of chest.

BROKEN PISTON VALVE STEM

Should you break the valve stem of a piston valve plumb the rocker arm disconnect the valve stem and clamp securely in position, then take off the front

steam-chest head, shove valve back against the stem and block between valve and head.

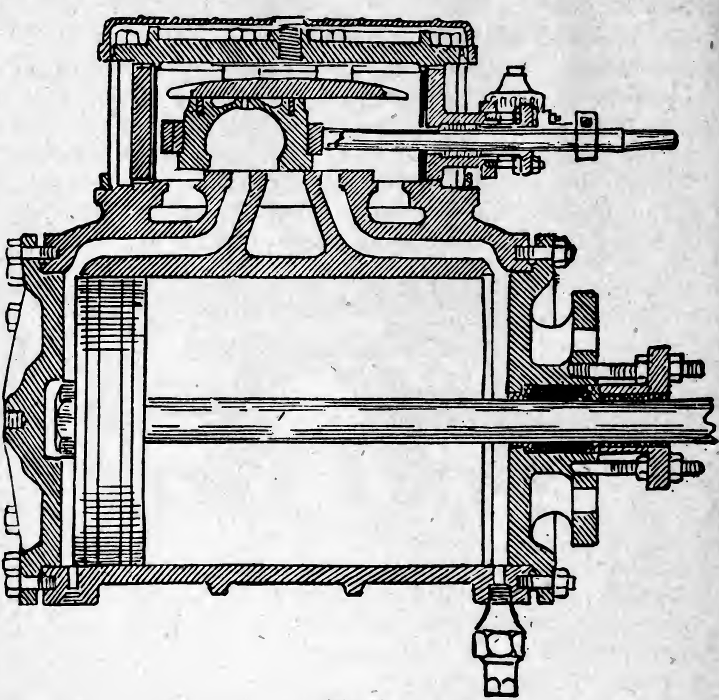


Fig. 38

BROKEN PISTON VALVE.

If the piston valve is broken, take off the chest head and if the valve is not to badly broken, place central on its seat and block from the head to the valve to keep form moving ahead. Disconnect the valve stem and clamp against the valve to hold from moving back, and if this fails to keep the valve in place, take off the back chest head and secure with blocks same as the front end, as shown in (Fig. 39).

Should the valve be broken so badly that steam cannot be kept from the exhaust, you will have to get ready to be towed in.

BROKEN VALVE SEAT.

Should the valve seat break, and it is a front admission bridge and the admission and exhaust ports

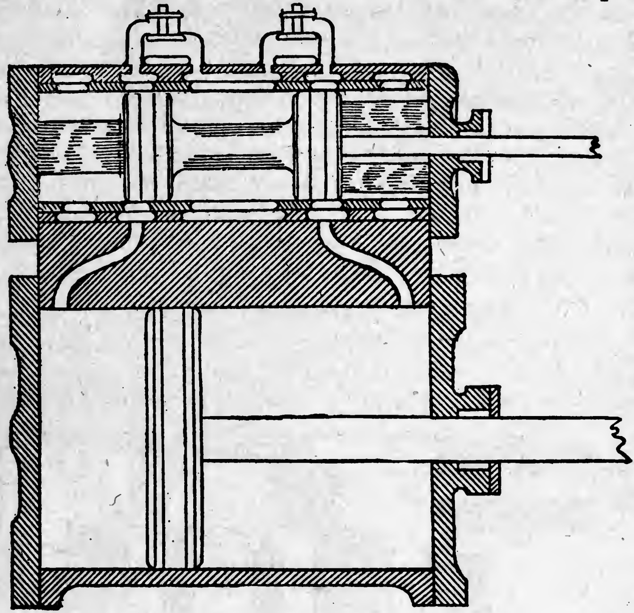


Fig. 39

can be covered as shown in (Fig. 40). Disconnect the valve stem and clamp securely; take down main rod and block at back end of guide. But should it be the back admission bridge that is broken, the valve should be moved ahead in just an opposite position as shown in (Fig. 40), the cross head blocked ahead, and the cylinder cock taken

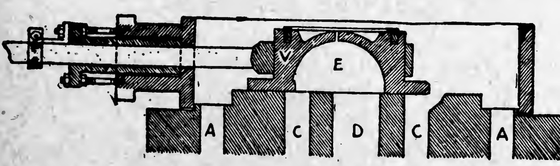


Fig. 40

out of the end of the cylinder at which the piston is

blocked. When blocked in this way, one end of the cylinder is in connection with the steam-chest which will admit steam to the cylinder and against the piston head, so good blocking should always be used. By taking out the cylinder cock it will allow steam to pass out of the cylinder. If the valve should in any way shift, and that would show you that the valve had moved from its position. If the cock was not taken out, and the throttle shut off, the pressure on one side of the piston would quickly escape and the accumulated pressure back of the piston would be very apt to move the piston and crosshead and thus cause more damage when you opened the throttle again.

BROKEN EXHAUST BRIDGE.

If the exhaust bridge should break,. the valve should be centered on its seat, the valve stem disconnected and firmly clamped in place as shown in Fig. 41.

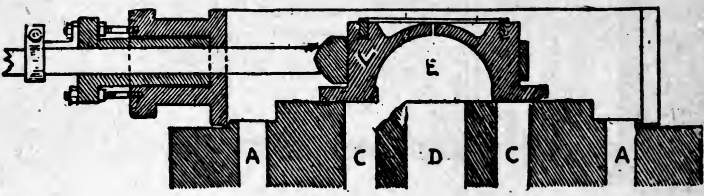


Fig. 41

The main rod taken down and the crosshead blocked at back end of guides. The reason the main rod is taken down is that pieces of the broken seat might get down into the cylinder and do more damage.

BOTH BRIDGES BROKEN.

Should both the admission and exhaust bridges break, the chest cover should be taken up and the supply ports to the steam chest blocked. The blocking must be built up so that the cover will hold it in place when put back on, as shown in Fig 36. You can leave the main rod up if all the broken pieces are found, if not it should come down and the crosshead securely blocked at back end.

BY-PASS VALVES.

A by-pass valve is a small valve, one of which is placed on each end of the steam-chest for the purpose of preventing excessive pressure. They are marked BB as shown in Fig 42. They are connected with the live steam side of the valve EEE and the steam port between the valve and cylinder FF. They are held to their seat by steam-chest pressure and are unseated when the compression in the cylinder becomes greater than the boiler pressure.

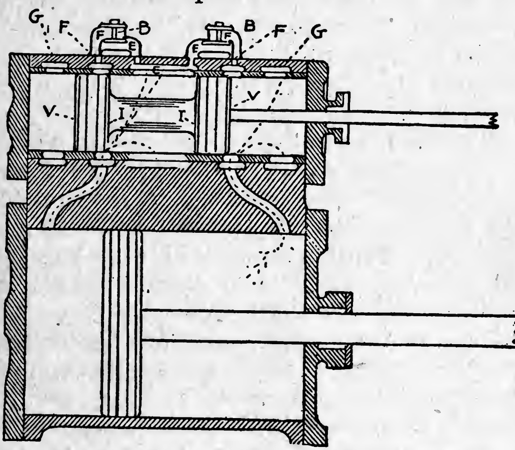


Fig. 42. Showing Piston Valve and Cylinder By-Pass Valves, Placed on Top of Steam Chest

Should you break a by-pass valve it should be tested for by covering the exhaust port with the main valve. If the blow then stops and steam appears at the cylinder cock it indicates a broken by-pass valve, and the cylinder cock that shows steam will indicate which by-pass valve is broken. A broken by-pass valve will cause a severe blow at the stack when the exhaust is open. Fig. 42 shows the back end of the cylinder open to exhaust, and also shows how steam can pass from E to F and out of the stack in case the back by-pass valve is broken in this position.

If the blow will prevent you handling your train properly to terminal, take off by-pass valve case and insert blind gasket between the by-pass valve case and cylinder casting. In some cases you may be able to block the by-pass valve in position by removing the cap.

BROKEN OR CRACKED STEAM CHEST.

This is a very troublesome mishap. If the chest is only cracked, remove the casing, and if it is only cracked on one side, by wedging between the chest and studs, as shown in Fig. 43, you may be able to close the crack enough to get in. If it is a bad crack or cover, and you have no way of clamping the broken parts, disconnect that side, and then the quickest remedy would be to use a blind gasket at one end of the steam pipe, but that is considered impracticable owing to the corrosion of bolts and nuts, the netting and a very hot front end, so remove the chest cover and plug up the supply ports (not the steam ports) with wood and clamp the plugs with the steam chest studs.

If steam enters from side of chest, use a gasket there. If the chest is completely knocked off, clamp your wood plugs with old bolts and fish plates, or whatever you can find. If you cannot make the ports tight, you can leave the train and run under light pressure to the nearest telegraph office and report to headquarters the condition of the engine. Remember, many steam chests can be saved where you have no relief valve by opening the throttle as soon as you reverse the engine, for the reverse valve gear is virtually an air pump, and if the air cannot enter the boiler it must escape somewhere when compressed, so away goes the steam chest.

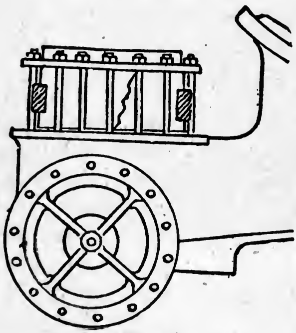


Fig. 43

BROKEN PISTON OR ROD.

When a piston rod breaks it generally knocks out a front cylinder head. When the piston is entirely out of the cylinder, or if it can be easily removed, do it, and it will not be necessary to take down the main rod. Simply cover the ports with the valve, disconnect the

valve stem and clamp to hold valve as previously explained and remove all loose or broken parts and proceed.

BROKEN PISTON AND VALVE STEM GLANDS.

If the gland breaks in two, try and wrap it with bell cord or wire. If a lug breaks off make a wood clamp. You have two nuts on each stud, so remove one of the nuts and tighten the other up against your temporary clamp. If you loosen one stud, wrap wire or rope around the steam chest and try to hold it securely, or remove part of the packing and shove the gland in further, and try to hold it with one stud. If all remedies fail, disconnect it on broken side.

METALLIC PACKING PLAYING OUT ON THE ROAD.

Take off the stuffing box or packing case, and if any of the old packing is left, leave a ring of it in the cone or cup. Then make out of wicking or old overalls, or even of waste, if nothing better is at hand, a ring of packing large enough to fill the space in the cone. Then push the cone back against the follower on the end of the spring. Put on your stuffing box and you are ready to go. The writer has known of cases where it has run several trips, and it will make a joint, too.

BROKEN CRANK PIN.

If it is a main pin, disconnect on broken side and remove all side rods. If a back pin on an eight wheel engine, remove both side rods. If a back pin on a ten wheel engine, remove the back set of side rods only, if the knuckle joint will allow. If a front pin on a ten wheel engine, remove the side rods only, providing the knuckle joint is right for it, and for a consolidation engine follow the same method as with a ten wheeler.

BROKEN CROSSHEAD.

A slight break, such as a gib or plate, may often be clamped so you can proceed, but be careful that the clamp does not strike the guide block at the extreme

travel of the crosshead. If it is a bad break, disconnect the broken side. If the piston is not broken, push it against the forward cylinder head and block the crosshead in that position. If the crosshead is broken so that it cannot be blocked, the safest way is to remove the piston. If it cannot be taken out, set the valve so as to admit steam to the back end of the cylinder only, and clamp the valve stem securely in this position.

BROKEN MAIN ROD OR STRAP.

Disconnect on broken side; take down main rod; disconnect the valve stem; cover the ports with the valve; block the crosshead, and proceed with train you can handle.

BROKEN SIDE ROD OR STRAP.

Remove the broken rod and the one directly opposite to it. If it is a ten wheel engine and this cannot be done, then remove all the side rods. If a front or back rod or strap on a consolidated engine, remove the broken rod and the one directly opposite to it. If this cannot be done, then leave the others up.

BROKEN ROD KEY SET SCREW.

When you want to remove a key from a rod and the set screw is broken, and cannot be backed with a chisel (if in the back end of the main rod), take the strap bolts out of that end of the rod and block the crosshead. Then with a pinch bar move the engine until the key is loose. If the set screw is broken in a parallel rod, take the bolts out of the strap where the further screw is broken, block the other drivers, and with a pinch bar slip the wheels until the key is loose. It does not take much slipping of the wheels.

LEAKY STEAM PIPES.

The leaking of steam pipe joints in the smoke-box is very disastrous to the steaming qualities of an engine, as it has a double action against keeping up steam, as all that escapes at the leaky joint is wasted,

and its presence in the front end interferes with the draft. If the steam pipe joints are leaking badly they can generally be heard when the fire-box door is open and the engine working steam. Some engineers can detect the action of leaky steam pipes on the fire, but the safest and surest way to locate this trouble is to open the front end and give the engine a little steam.

IN CASE OF BURSTED FLUES.

When a flue bursts it generally kills the engine by putting out the fire, but if not, reduce the steam pressure and plug the flues. A wooden plug will do if you have no iron one. If you can get at the flue from the fire door (a long rod is usually furnished each engine for this purpose), you can plug it without drawing the fire. A sharpened pole or young sapling long enough to reach the flue may be driven into it. (The wood will not burn inside the flue sheet.) If this cannot be done, then cover the fire dead, open the blower a little to carry off the smoke in the fire-box and reduce the pressure as low as possible with the blow-off cock and injectors. Then lay a board on top of the coal and go into the fire-box and plug or caulk the flue. Of course, this cannot be done if there is a brick arch in the fire-box.

BROKEN WEDGE BOLT.

It is sometimes possible to screw the nut part way on the two ends of the broken bolt, and in that way hold it together and up in its place. If this cannot be done, then with a wire try and fasten a nut under the wedge to hold it up in its place, and have a new one put in at the end of the trip.

A STUCK WEDGE OR BOX.

Loosen the jam nut on the wedge bolt on top of the pedestal or binder brace and pull down on the wedge bolt. If the driving box was hot, would cool it off first. If the wedge did not come down easily, would run driver over a nut or the coal pick or chunk of hard

wood. By cooling off the box and putting a tension on the wedge bolt and oiling the wedge good, the box will often work loose in running to the next stop. There is no such a thing as a stuck wedge. It's the box that sticks on account of the wedge being set up too tight. Lack of oil between the box and the face of the wedge, or the expansion of the box from heating, causes the box to stick.

BROKEN SAFETY VALVE SPRING.

Remove the cap, if there is one on the top, and screw down the adjusting screw as far as it will go. If the jamb nut prevents the screw from going down far enough(split the nut and screw it down far enough to hold the valve solid to its seat. The broken pop valve spring will render the valve inoperative, but the other pop will relieve the pressure until you arrive at a terminal. This is one reason why two or more pop valves are used on locomotives.

BROKEN SMOKE-BOX OR FRONT END.

Board it up as close as you can, using fence boards or anything you can find, grain doors out of an empty car, or even a car door, if nothing better is at hand. Use the front end bolts to hold the boards in place. Then take the back curtains out of the cab and it will improve on the job a whole lot.

BROKEN WATER GLASS.

Shut off both cocks, and use gauge cocks until you have a chance to put in a new glass. You should always have an extra supply on hand. The gauge cocks should also be used quite often if the water glass is not broken, as it keeps them from stopping up, and you will have them when wanted. They are much more reliable than the glass anyway.

LUBRICATOR WILL NOT WORK.

Try and blow the lubricator out with steam, as it sometimes gets stopped up, and can be started in this way. If all other methods fail, you will have to discon-

nect the oil pipes and shut off steam, and oil through the pipes frequently . (See Chapter on Lubricators for remedy.)

POP OR WHISTLE BLOWN OUT.

In a case of this kind the first thing to do is to start both injectors in order to retain as much water as possible. Kill or smother the fire, and as soon as cool enough drive a soft wooden plug into the hole. See that you have enough water in the boiler. Then fire up again, but keep the steam pressure as low as you can to avoid blowing out the wooden plug, and proceed.

Another Good Way—Is to whittle a soft wooden plug about twelve inches long. Make it about one inch larger at one end than the hole is in diameter, and taper to three-quarters the size of the hole at the other end. Saw it or split it in four quarters and tie a string on the small end of each piece and drop them into the hole one at a time, retaining a hold on the string, and pull them all up evenly together by means of the strings. Of course, you will have to reduce the pressure before you can work, and by the time you have gotten up steam again, the plug will make nearly a steam tight joint and you are ready to go.

BOTH INJECTORS FAIL TO WORK.

You should do everything in your power, or that you can think of, to get them to work, and if everything fails and they positively refuse to put water into the boiler, why, all you can do is to get the engine ready to be towed in, but before doing this, remember that to a certain extent your reputation is at stake. (See the Chapter on Injectors for their troubles.)

DISCONNECTED THROTTLE VALVE.

Should the throttle valve become disconnected while running, and it does not seat, set the brakes, put the reverse lever in center notch of quadrant and reduce steam pressure as fast as possible. When pressure is reduced so the reverse lever can be safely hand-

led, open the cylinder cocks, set the brakes, and move the lever quickly ahead, and then back on center. This causes a sudden movement of steam through the throttle valve and will often cause it to close. If this is not effective, get on to the nearest siding and notify the proper authorities. The engine can be run in under steam, but it is not a good plan to try to handle a train with the large engines any further than to get it off the main track. If the throttle is closed when it becomes disconnected, notify headquarters and get ready to be towed in. Keep steam enough on the boiler to work the lubricator, and it will not be necessary to disconnect the engine. About the quickest way to reduce steam pressure is to blow steam back through the overflow pipe of one injector, put water into the boiler with the other one, open fire door and crack the blower a little as it assists to cool the fire-box.

BROKEN DRIVING BRASS.

If a driving brass breaks and is cutting badly, run that wheel up on a wedge. Then place an iron block between the top of the frame and the spring saddle, which will take the weight off the box where the broken brass is.

ENGINE TRUCK BRASS BROKEN AND NO BRASS AT HAND.

Raise up the box off the journal and cut a piece of hard wood to put in the place of the brass. Run this as far as it will go, and then renew it as often as is necessary to insure absolute safety. Pack the cellar just as you would for a proper brass, and it is a good plan to put a bucket or two of water on it every stop you make.

BROKEN DRIVING OR TRUCK CELLAR.

Should a driving box cellar, its lugs, or an engine truck cellar break, a temporary one can be made out of wood, and a piece of rubber hose tied to the binder to hold the cellar against the journal. The rubber hose

will act as a spring for the up and down movement of the boxes.

GRATES BROKEN OR BURNED OUT.

If a grate is broken or burned out, or entirely gone, you can usually build or block up under it with stone or brick or anything that is at hand that won't burn. Use angle bars or scrap iron across the space to keep the fire from falling into the pan. These can generally be found around the hand car house of any section. Keep the ash pan clean, and you will have very little trouble of this kind.

BROKEN ROCKER BOX.

If it cannot be clamped or blocked securely, then disconnect that side. If you can remove the rocker arm, it will save taking down both eccentric straps, but if you cannot remove the rocker arm without difficulty, then remove both eccentric straps and tie the top of the link to the short arm of the tumbling shaft, to prevent the link from tipping over.

BROKEN GUIDES, BLOCKS OR BOLTS.

Should any of the bolts break or are lost, try and replace them. See that all nuts are tight, or they may be the cause of springing the piston. If the guide bars are broken badly, disconnect on that side.

BROKEN GUIDE YOKE.

If the guide yoke is bent badly or broken so it will not hold the guide in place, disconnect on the broken side.

LOST MOTION BETWEEN ENGINE AND TENDER.

The lost motion between engine and tender should be reported taken up when there is enough to cause a strain on the drawbar by the forward or back lurch of the engine while in motion, or when starting.

GETTING ENGINE OFF CENTER.

Should an engine, disabled on one side, stop on the center, and the main rod and piston was left up, she can be started by moving the valve on the disabled side by hand just enough to admit steam enough to move the good engine off the center. Then the valve must be placed in its former position and again clamped.

Another Method—Is if your engine has the push out type of driving brake cylinder hung under the running board, disconnect the brake fulcrum from its connection with the brake cylinder piston so the brakes will not set on the engine, and get the switch pole, or a tie will do, and put one end against the brake piston when in release position and the other end against a solid tie in the track, and set the air very carefully until you take up all the slack or space between your tie and brake piston. Then set it hard and your engine will move off the center all O. K.

LOOSE CYLINDERS.

The cylinders are fastened to the frame by means of cylinder bolts and keys. Should a key work loose you should drive it securely in, and if it is lost you can replace it with a piece of iron such as an old rod key or railroad spike. If you can't do this, the valve should be disconnected and clamped to cover the ports, and the engine go in on one side to avoid more serious trouble.

TO FILL THE BOILER ON THE ROAD.

Should you lose all the water out of your boiler from any cause, and wish to fill it again, and can get an engine to tow you a few miles, all you have to do is to open up the injector throttle and lazy cocks, put the reverse lever in full gear in the direction you are going to be towed, and open the main throttle valve. Take the cover off the man hole of the tank, and the pistons will pump the air out of the boiler, and the atmospheric pressure in the tank, along with the vacuum created, will force the water into the boiler. This, to

my notion, is the quickest and easiest way to fill a boiler out on the road, providing you have an engine to tow you.

BLOWOFF COCK STUCK OPEN OR WASHOUT PLUG BLOWING OUT.

Sould a blowoff cock stick open and won't close, or a washout plug blow out on the road, the first thing to do is put both injectors on and protect your boiler by drawing or deadening the fire. Should it occur in freezing weather, all parts of the boiler and all pipes containing water should be drained, and care should be taken when draining the tank so as not to let the water wash away the gravel from the bed of the road or flood any switches so they will freeze up. If it is not freezing weather, the blowoff cock should be taken apart and repaired, or the washout hole plugged and arrangements made to refill the boiler, or you must be towed in.

BROKEN REVERSE LEVER.

Should the break occur in the reach rod hole or below it, you you must apply the same remedy as for top arm of tumbling shaft or reach rod. Should the break occur above the reach rod connection, you can usually hold it intact by fitting blocks inside the quadrant, as shown in Fig. 44.

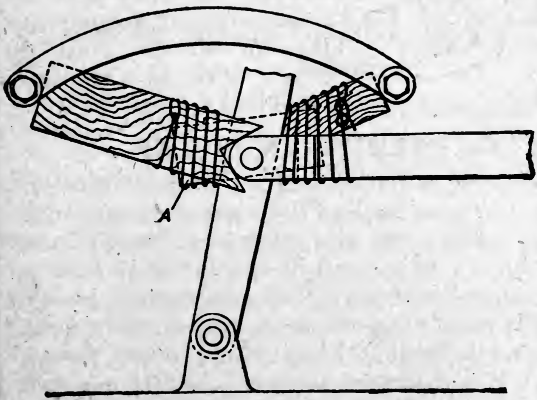


Fig. 44. Blocking for Broken Reverse Lever

If it is a solid quadrant, then any place you can secure a brace that will hold.

BROKEN REACH ROD, LINK HANGER OR SADDLE PIN.

When the link is blocked on account of one of these parts being broken, there should be a block placed between the top of the link and link block in such a position as to insure the handling of the train in forward motion, and a block between the link block and the bottom of the link, allowing enough space between the blocks for the slip of the link on the link block, as shown in Fig. 45. Then when it is desired to block the link for the back motion (which would have to be done in case you wanted to reverse the engine), the blocks should be reversed, using the long block on the top of the link block and the short one for the bottom of the link. Don't forget and try to reverse your engine without changing the blocks first.

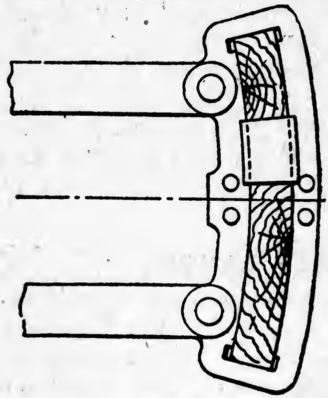


Fig. 45
Link Blocked at Top and Bottom

WATER FOAMING IN BOILER.

As it is oil and other impurities in the water that cause a boiler to foam, and as they always come to the surface of the water, and you have a surface blowoff, it is an easy matter to get rid of them, but if your engine is not equipped with any kind of a surface blowoff, then open the cylinder cocks, close the throttle gently till the water settles solid, then try how much water is in the boiler. Put injectors to work, and if necessary open the throttle gently and work the foul water through the cylinders. Close the throttle often and try the water. Be very careful in admitting steam into

the cylinders or you will knock the cylinder head out. If the cause of the foaming is found to be grease in the tank, flow the tank over when you take water. If you can get about one-fourth of a peck of unslacked lime, put it in the tank, or a piece of blue stone about the size of a hickory nut, put in the hose back of the strainer, will prevent foaming. This can be had at any telegraph office along the line.

BROKEN LINK.

With a broken link, disconnect on broken side. Remove both eccentric blades and straps on broken side. Remove broken link, or fasten the top of it to the tumbling shaft arm with wire or bell cord. Should both links be broken, get the engine ready to be towed in.

BROKEN EXTENSION ROD.

The engine truck sometimes bends or breaks the long extension rod which connects the link block and rocker arms on a ten wheel engine. Should this happen, disconnect on the broken side, and remove the extension rod and proceed.

BROKEN TUMBLING SHAFT, ITS ARMS OR STAND.

Should either tumbling shaft or stand get broken so badly that it cannot be clamped in some way and used, it is sometimes possible to use a wooden block in its place. Should the top arm of the tumbling shaft get bent or broken, it is sometimes possible to use a pinch bar or other iron rod across the engine frame, to hold the short arm in working position. If a pinch bar or iron rod is used, see that it doesn't interfere with the eccentric rods, and fasten it securely. If a rod cannot be used, then the link must be blocked. Fit a piece of wood in the slot between the top of the link and the link block for the link to rest on; make the block long enough to hold the link as high as you desire the engine to cut off, and tie the block securely in its place.

It is not necessary to block both links. Run carefully. If you wish to reverse the engine, you must first reverse the blocking, using a longer block on top of the link. If one short arm of the tumbling shaft gets bent or broken, remove the link lifter on that side and block one link as previously explained. Should both the short arms get broken, remove both link lifters and block both links, and proceed.

BROKEN ECCENTRIC STRAP, BLADE OR ECCENTRIC.

In case of a breakdown of this nature the safest way would be to remove both eccentric straps and tie the top of the link to the tumbling shaft arm to prevent it from tipping over. Then disconnect the engine on the broken side. If only a jaw of a back motion strap breaks off, or a hole breaks out, it is sometimes possible to fasten the blade to the other strap with a long bolt. Remove the broken strap, and if the temporary bolt is used and the link will clear everything during one complete revolution of the wheel, then you may proceed slowly without disconnecting, but don't try to run backwards. If the forward motion eccentric or strap is disabled, you must disconnect the engine on that side, but it will not be necessary to remove the back motion eccentric strap. If left on the link lifter on that side must be taken off.

SLIPPED ECCENTRICS.

Since the practice of keying the eccentric to the shaft has become so general, these mishaps occur less frequently than formerly, yet every engineer should know how to reset a slipped eccentric. This accident is easily detected, for, without any warning, the exhaust will become very irregular and you may lose one exhaust. You should stop at once and go under the engine, when the cause will be quickly discovered. If you have previously studied the positions of the different eccentrics on the shaft, it will be an easy matter to reset it, but if you are not familiar with the relative

positions of the eccentric, you may experience considerable trouble. In all standard engines with indirect motion, when the crank pin is on the forward center the go-ahead eccentric will be above the pin, and the back-up eccentric below the pin. When the pin is on the back center their positions are reversed. The rib of each eccentric is set about the third spoke in the driving wheels away from the pin. The spokes in the different wheels may vary, but so does the lead and lap. Always remember that they should be at right angles with the pin, but each should incline slightly toward the pin. Perhaps the quickest way to set a slipped eccentric approximately correct is the old way of marking the valve stem, which is as follows: Place the crank pin on either dead center on the side that has slipped. The forward center is the most convenient if the forward eccentric has slipped. (The forward motion is usually attached to the top of the link.) Place the reverse lever in the extreme back notch of the quadrant, and with a knife, or any other sharp instrument, scratch a line on the valve stem as close as possible to the gland. Now put the lever in the extreme forward notch, then move the eccentric around until the mark you made on the valve stem appears, then fasten the eccentric in that position. If the crank pin is on the forward center, the center of the eccentric should be above the pin, and if on the back center, below the pin. Should the back-up eccentric slip, go through the same performance in exactly the reverse manner, by placing the lever in the forward notch, first marking the valve stem, then put the lever in back notch, and set the eccentric as before.

To Set Both Eccentrics.—Should both eccentrics on the same side slip at one time, set each eccentric as near as possible to the position we have already stated. Now place the crank pin on the forward center, block the wheels, open the cylinder cocks, place the reverse lever in the back notch, and give the engine a little steam. Now move the back-up eccentric until steam

appears at the front cylinder cock. Then fasten the eccentric. Now put the lever in the forward notch and move the other eccentric until steam appears at the same place (forward cylinder cock), then fasten it and you are ready to go.

Another Method—Is to get the engine on its dead center as nearly as you can by the eye, and if the forward motion eccentric is slipped, hook the reverse lever clear back, clamp the valve stem so that the valve cannot move, take out the bolt that connects the forward motion eccentric rod to the link, put the reverse lever clear ahead, being careful that the valve does not move. Then, by moving the eccentric on the shaft until you can put the jaw bolt in, the eccentric will be near enough right to run in with, only be careful that the eccentrics are not in the same position on the shaft, or you will have both set for the same motion. One eccentric must point up, the other down. A back motion eccentric can be set in the same manner, only to start with put the reverse lever in ahead before clamping the valve. After clamping, take the jaw bolt out of the back-up rod and move the back motion eccentric till the bolt will go in without moving the valve or rocker arm. When an engine is on its dead center, the valve should be in exactly the same position, when the lever is in the extreme back notch, as when in the extreme forward notch, so if the valve rod does not move while the bolt is out and the reverse lever is being moved, the eccentric will be nearly right after the bolt is put in. The valve rod will move while the lever is being moved, but in both extreme notches will show that the rod is in exactly the same place.

Another Method.—Another quick, and, to my notion, the handiest way to set a slipped eccentric, is to put the engine on a dead center on the slipped side, and the reverse lever in the center notch of the quadrant. Take a piece of string long enough to make a plumb line by tying a nut or bolt or any weight to it. then hold one end of it to the center punch mark on the

end of the blade or jaw bolt, and have the fireman turn the slipped eccentric on the shaft till the other blade or jaw bolt center punch mark comes in line. That is, have them straight up and down, which you can do by means of the plumb line, then fasten your set screws and you are ready to go.

SLIPPED ECCENTRIC BLADES.

This defect is easily detected by the irregular exhausts. They can be set by placing the crank pin on either center, reverse lever in forward notch, and open the cylinder cocks. Adjust the blade until steam appears at the front or back cock, according to the position of the crank pin. If the pin is on forward center, steam should appear at front cock, and if on back center, at back cylinder cock, or it can be set by marking the valve stem, the same as for a slipped eccentric.

BROKEN ROCKER ARMS.

Should a top arm break, disconnect that side. Should the bottom arm break, disconnect on broken side. Remove the broken part of the rocker. If the link will then clear everything you can leave the eccentric strap up, but you must be certain that it will clear everything in both gears. If it doesn't, remove the eccentric straps, then tie the top of the link to the short arm of the tumbling shaft to keep it from tipping over, which might prevent reversing the engine.

BROKEN ROCKER PINS.

If the top one should break, replace it if you have an old one. If not, then disconnect that side. If the bottom pin breaks, it is sometimes possible to remove the top pin and turn the bottom arm up high enough to clear the link. Then tie it up to the guide yoke, but you must be sure that it will clear the link when in full gear in both motions. If you are in doubt, remove both eccentric straps, then tie the rocker forward or back to clear the link, and tie the top of the link to the short arm of the tumbling shaft to keep it from tipping

over. You can use bell cord or wire for this purpose. Then disconnect both sides.

BROKEN ELIC BOLT ON MOGUL ENGINE.

If the elic bolt should break, you will have to block up between truck axle and forward end of the long intermediate equalizer. Place a truck brass on the axle and allow the end of equalizer to rest on it. Oil the brass well and you can get in without much trouble.

BROKEN ENGINE DRAWBAR.

If the engine has safety chains they will hold the tank, but not always a heavy train. If the engine is not equipped with safety chains, then secure a chain from the tank box or the caboose or baggage car, as the case may be, and chain the tank to the deck of the engines. Safety chains should not have more than three or four inches of slack in them.

BROKEN DRIVING SPRINGS AND HANGERS.

With the heavy engines now in use, road men are not expected to jack up the engine, and even if you have a small engine, the quickest way is to use a wedge on the rail when possible to do so, as time is usually an important consideration, but it should be done carefully, or you may break other springs or hangers, or the engine may leave the rail. If an eight wheeled engine, and a forward spring or hanger should break, place a fish plate or other piece of iron between the top of the back driving box and frame on broken side, which will save raising the wheel that much higher and permit of a thinner wedge being used. Now place a wedge upon the rail and run the back wheel upon it, which will take the weight off the forward driving box. Now block solid with wood between the top of the forward box and the frame. Then remove the spring saddle if necessary. Now let the engine down and remove the fish plate from the back box and relieve the equalizer and block it solid. Then let the engine down, remove all loose parts, and you are done.

If the back spring or hanger is broken, go through the same performance in the reverse manner by running the main wheel upon the wedge first. If it is a mogul, or ten wheel engine, to raise the weight of the main wheel, run the forward wheel upon the wedge first, and to take the weight off the forward pair run the main wheel upon the wedge. If a mogul engine, and a forward spring or hanger broken, you may have to remove both forward springs, and block on top of both forward driving boxes, but if it is only a hanger, remember a chain may sometimes be used to replace it. When you block both forward driving boxes, you must also block the intermediate equalizers to truck. When the springs and equalizers are below the frames, proceed in the same manner, then block or chain up the equalizer until level, and remove or secure broken springs or hangers. When the spring hangers straddle the frame, it is sometimes possible to block between the hangers and frame. Should the large spring below the frame break, block on top of both boxes, or block between both long hangers and the bottom of the frame, and remove or secure broken springs or equalizers. Should the small coil spring hanger, back of the rear drivers, break, it may be possible to remove one of the small equalizers which ride the back driving box. If not, and you cannot hold the spring hanger any other way, you may be able to chain the back end of small equalizer to frame. If not, you will have to let the frame ride the driving box, but run slow if you do.

BROKEN ENGINE AND TRUCK EQUALIZERS.

Raise the engine the same as for a broken spring or hanger, when possible to do so. If an equalizer on an eight wheel engine, block on top of one box and block up the loose end of the equalizer when possible, the same as for a broken spring or hanger. If it cannot be used, remove the equalizer, and block on top of both boxes. If an equalizer below the frame, do likewise, or chain it up. If forward equalizer on a ten

wheel engine, block on top of forward and main boxes, and block up forward end of back equalizer. If it is the cross equalizer on a mogul engine, block on top of both forward boxes, also block on top of the back end of the long intermediate equalizer. If it is the cross equalizer on a four wheeled pony truck, block on top of both forward driving boxes. When the equalizer is below or between the frames, it is sometimes possible to block between the hangers and the frame. If a small equalizer that rides the back box, block on top of the back box and chain up back end of bottom equalizer. If it is a truck equalizer, block on top of truck boxes between the box and truck frame. Always remove or secure all loose or broken parts before starting.

BROKEN EQUALIZER STANDS.

If the equalizer stand breaks, then use the same remedy as for broken equalizer. If only the bolts break, you may be able to find some bolts to replace them, in some other part of the engine or a car that will fit, and the loss will not impair the working of the car or engine you take them from.

EQUALIZER BROKEN, REACH ROD BOUND, ENGINE HOOKED UP NEAR CENTER NOTCH AND WON'T MOVE HERSELF.

If you have no jacks to raise the engine, she must be made to raise herself, which can be done as follows: First of all, take out the pin in front end of reach rod, and put the links down in forward motion. Get a long piece of plank or other solid material and lay on the rail in front of the front driver. Chamfer off the end of the plank, making it wedge shape. After you are all ready to run the wheel up, have the fireman stand ready with a good block, to stop and hold her when you get the wheel up on the wedge. After you get the front wheel up, put a piece of iron between top of back driving box and frame. Then run her ahead until the back wheel comes up on the wedge and the front one

drops off of it. Put another iron between top of front box and frame, and you will find your reach rod loose. When you run her off the wedge, put your pin in the end of the reach rod that you took out, and you are ready to go.

BROKEN ENGINE TRUCK SPRING OR HANGER.

First raise the front end of the engine, with jacks or fulcrum block. If it is a four wheeled truck, pry up the frame on the broken side and block between the equalizer and the truck frame, close to the spring band, keeping it up level with the other side. If a mogul truck, then block between the top of the truck box and the truck frame, and go on.

BROKEN TRAILER SPRING OR HANGER.

When a trailer spring breaks, it allows the end of the broken spring to drop into the safety hanger. First jack up the end of the cross equalizer into position and place a block in the U shaped safety hanger to hold it until you are ready to remove it. Now raise the back end of the engine frame so she will ride level. Remove the broken spring, and take a tie or a piece of rail, and place it over the trailer box, and chain front end to the cross equalizer, and the back end to the frame and hanger pin. Remove the block from the safety hanger under the cross equalizer and let the usual load come on the trailer box. If a front hanger on a trailer spring should break, raise the back end of the engine on the disabled side, so as to relieve the trailer spring. Then jack up the end of the cross equalizer, next to the broken hanger. Pry down the front end of the trailer spring, and securely chain the end of the spring to the end of the cross equalizer. If a back hanger on a trailer spring is broken, raise the back end of the engine, and also jack up the end of the cross equalizer to relieve the spring. Then pry the back end of the spring down and chain it so it will not work off the hanger pin.

BROKEN CENTER CASTING.

If a truck center casting should break on a standard four wheeled truck, jack up the front end of the engine. If you can find two short rails, place them across the top of the truck equalizer and under the center casting. If you can't get any short rails, block up both sides between the truck frame and cylinder saddles. In this case, run very slow around curves, as the engine will not track very well. If the top or male casting breaks, you must block up the same way. If a pony truck center casting breaks, block between the truck frames and the engine frame on each side, but run slowly around curves.

BROKEN ENGINE FRAME.

If a single frame is broken between the main drivers and the cylinders, the broken side of the engine should be disconnected and the engine go in light. If it is a double frame and does not open too far, the engine should take as many cars as can be handled without further damage. If there is any danger of doing more damage, go in light. Be very careful when starting. If it is the lower rail of the frame that is broken, start the engine and see how far it will open up, and if no danger of breaking the upper rail of the frame, take your train and go. Should the top rail of the frame break back of the main driver, the side rods should be taken down. Then the engine can go with what cars she can handle without doing further damage. If the break is in the lower rail of the frame, you can generally take in your whole train, as it will not be necessary to remove the side rods in that case.

BROKEN ENGINE TRUCK FRAME.

Raise the weight of the engine off the broken truck frame, and place piece of heavy iron between the equalizer and the truck frame, or often a piece of rail or heavy iron may be chained to the broken frame in the form of a splice so it will hold till you get in.

ENGINE OFF THE TRACK.

If the engine is in such a position as to leave the crown sheet or flues unprotected by water, draw the fire, or if you cannot draw it, smother with earth, sod, snow or fine coal. Ask headquarters at nearest telegraph office for assistance. The first thing to do, after protecting yourself from approaching trains, is to see if the boiler is high enough at either end to leave either the crown sheet or front end of the flues unprotected by water, for with a hot fire, if these parts are not well covered with water, either of them may become red hot and may burn, or even melt the metal in a short time. Most engines, if not off very badly or too far from the track, will help themselves on without the aid of another engine, by using blocking under the wheels that are off. If you have jacks they will aid materially by setting them to push the engine. Engines can usually be put on the track easier by moving them back the same way they came off. Do not ask for help if you can possibly get along without it.

BROKEN DRIVING AXLE, WHEEL OR TIRE.

An accident of this kind is a very serious breakdown, as it may strip one side of the engine or perhaps disable it, but in most cases of this kind the engine can be blocked up so as to reach the nearest siding, if not terminal. If the injury is slight, by running slow and being careful, the nearest siding may be reached, where you can notify headquarters and where the engine should be properly blocked to run to the shop without assistance, but it implies considerable work and judgment of the engineer, so I will take up and treat these various mishaps separately.

MAIN WHEEL BROKEN OFF THE AXLE.

Disconnect on the broken side and remove all side rods and broken wheel. The eccentrics will prevent the other main wheel from leaving the rail even though it be a blind tire. Use a jack and raise the axle on the broken side. Remove the oil cellar and fit a hard wood

block between the axle and pedestal jaw or binder; then use old rod keys or any kind of iron and block between the spring saddle and the top of the frame, to keep part of the weight off the axle at this point. Then remove the jack. Now raise the engine slightly on broken side by running her up on wedges. Then block between the top of the driving box or boxes nearest the broken wheel on broken side, using hard wood or iron. If it is an eight wheeled engine, also block between the engine truck equalizers and the truck frame on both sides, as additional weight will be imposed upon the truck. If a consolidated engine, it will only be necessary to block on top of the two boxes nearest to the main box. Then let the engine down and proceed slowly.

FORWARD WHEEL BROKEN OFF THE AXLE.

Remove both side rods between the forward and main pair of wheels. If this cannot be done, then remove all side rods, and remove the broken wheel, or chain it up clear to the frame. Now use a jack and raise the axle on the broken side. Remove the oil cellar and fit a hard wood block between the axle and the pedestal jaw or binder; then block under the spring saddle on the broken side. Now if the forward pair of wheels have blind tires, then, unless there are collars on the axle, the opposite wheel must also be raised and blocked to clear the rail. In this case raise the front end of the engine and block on top of each main box and on both truck equalizers; and if a pony truck, on frame and the engine frame on both sides. If it is a six wheel connected engine, without an engine truck, block on top of the main boxes and under the back boxes, which will tend to counterbalance the weight. If necessary to disconnect the forward pair of springs on a mogul engine, an old truck brass may be used between the truck axle and the long equalizer, but if the forward pair of wheels have flanges, or collars on the axle, let the good wheel run on the rail and block on top of its driving box and on top of the main box on

the broken side and the truck equalizer, as explained. See that the forward crank pin on the good wheel will clear the crosshead in all positions. If it will not, then both sides of the engine must be disconnected and the engine towed in, but assuming that it will clear, then proceed slowly, especially around curves, as the engine may not curve well.

BACK WHEEL BROKEN OFF THE AXLE.

Remove both side rods between the main and back pair of wheels and all side rods if necessary. Place a jack under the axle and raise the broken end. Remove the oil cellar and fit a hard wood block between the axle and the pedestal brace or binder on that side. Also block under the spring saddles and let the good wheel remain on the rail and block on top of its box, and drive wedges between the drawbar and the chafing iron and block on top of both main boxes. Leave your train and run carefully. If the axle should be broken between the two driving boxes, try to remove both wheels. If this cannot be done, they must both be blocked up high enough to clear the rail, and if it is a heavy engine, part of the weight of the engine must be transferred to the tender. Block between the equalizer and the engine truck frame on both sides. Then raise the back end of the engine and block on top of both main boxes, and wedge between the drawbar and chafing iron. If this can be done you may still run the engine in light, but if it cannot be done, then run a short piece of rail into the fire box door and chain it to the drawbar and block up under the back end of the rail on the tender. If the latter method is followed the engine must be towed in, so get her ready.

TIRE BROKEN ON MAIN WHEEL.

If it is only a bad crack, or even broken through, if the tire is still on the wheel, let the fireman stand on the steam chest and watch it while you run slow, and try to reach the nearest siding. Now if the tire is very loose, take off the rods and remove the tire,

disconnect on broken side and remove all side rods. Then place a jack under the axle and raise the wheel with the broken tire. Remove the oil cellar and fit a hard wood block between the axle and the pedestal jaw or binder, and also block under the spring in order to keep the weight off the box. Now remove the jack from under the axle, and raise the engine on the broken side and block between the top of the driving box and the frame on the boxes, or box next to the main wheel on that side. If it is an eight wheeler or a consolidated engine, block the boxes the same as for a main wheel when broken off the axle. Now let the engine down, and if the wheel clears the rail proceed slowly. If it will not clear the rail block the engine a little higher on the broken side. If you cannot remove the tire and it will not let the wheel revolve, disconnect on both sides, and prepare to be towed in. Block up the main pair of wheels high enough to clear the rail on both sides, then block on top of all other driving boxes, and if an eight wheel engine, block on top of the truck equalizer.

TIRE BROKEN ON FORWARD WHEEL.

If the tire is on the wheel, try to keep on going until you reach the first side track. Then remove both side rods between the forward and main wheels. If this cannot be done remove all side rods. Then if the tire can be removed, take it off and block up the wheel. If you cannot remove the tire, block up the wheel on that side so the tire will clear the rail, but if the tire is bent or twisted in such a manner as to prevent the wheel from turning, then both wheels must be blocked up to clear the rail. Block them the same as for forward wheel broken off the axle. Some engineers claim that the side rods may be left up by simply slacking both rod keys, but it is not considered a good plan. It is much safer to remove the two forward parallel rods if it can be done conveniently. Then proceed carefully.

TIRE BROKEN ON BACK WHEEL.

Try to keep the tire on till you can reach the nearest siding. Run very slow and carefully. Then remove both side rods between the rear and next pair of wheels, and all side rods, if necessary. Also remove the tire if you can and block the wheel up to clear the rail. If you cannot remove the broken tire and it will not allow the wheel to revolve, both wheels must be blocked up to clear the rail. Block them up in the same manner as for the back wheel broken off the axle, and proceed.

TIRE BROKEN ON TRAILER WHEEL.

When a trailer tire breaks, run the wheel up on a wedge, a little higher than the thickness of the tire. Remove the cellar and place a hard wood block between the bottom of the journal and the box. A block should then be placed between the bottom of the box and the pedestal, the cross equalizer blocked up in the safety hanger, or the equalizer chained to the frame, and a rail or tie placed over the deck of the engine and the deck of the tank and chained to the main frame. Use wedges to take up the slack in the chain. With this method of chaining you can hold up the back end of the engine and also keep the good wheel to the rail while going around curves.

TIRE BROKEN ON BACK AND FORWARD WHEEL, ATLANTIC TYPE ENGINE.

If a back or forward tire should break on an Atlantic type engine, the wheel should be run up on a wedge, the oil cellar removed and a block of hard wood put in its place. Then it should be blocked solid between the substituted cellar and the pedestal brace, also put a block between the spring saddle and the frame. If you cannot remove the cellar, a nut or block of iron should be put between the pedestal brace and the jaws of the driving box, and blocks put between the pedestal and the cellar to hold the cellar in place.

BROKEN ENGINE TRUCK WHEEL OR AXLE.

If a piece of the flange is broken off of a truck wheel, run very slow, especially over frogs, switches and crossings. If a piece be broken out of a truck wheel, it is sometimes possible to chain the wheel to a timber placed across the track so as to slide the wheel to the nearest siding, where the pair of wheels should be removed and new ones put in, or they should be blocked up to clear the rail. If it is a four wheeled truck, chain the broken end of the truck frame to the engine frame. Then raise the engine and block solid between the truck box and truck frame, and between the truck frame and the engine frame above the good pair of wheels. Also block on top of the forward driving boxes. Leave your train and run slow, especially around curves. If it is a two wheeled truck, the truck frame should be chained to the engine frame and then the front end of the engine should be raised high enough for the truck wheels to clear the rail, and then block solid between the frames, also on top of the two forward driving boxes, and under the two back driving boxes. (Be careful not to break the back driving box cellar.) This will help to hold up the front end of the engine. Place fish plates on top of the back driving boxes before you raise the front end of the engine. It will prevent breaking the driving springs or hangers. If a truck wheel is broken off or the axle badly bent, block up the same way, and it is sometimes easier to remove the truck entirely, and there have been cases of this kind where a pair of wheels or a whole truck was taken from a car and substituted for the broken ones.

BROKEN TENDER WHEEL OR AXLE.

If you can find a piece of rail the right length, or a cross tie will answer, place it across the top of the tank directly over the broken pair of wheels. Block under the rail or tie to protect the flange on the top of the tender. Jack up the broken pair of wheels to clear the rail, and while in this position chain the truck to

the rail above the tank on both sides, and you are ready to go.

BROKEN TENDER TRUCK SPRING.

Should a tender truck spring be broken, you will have to jack or fulcrum up the tank on the side or corner on which the spring is broken. If a semi-elliptic spring, extending from one truck box to the other, the blocking should be placed between the top of the bolster and the bottom sill of the tender. If a swing truck, place the blocking between the bolster and the sand board instead of the spring.

HOW TO GET OUT SHEARED ROD BOLTS.

After you have tried all other means at hand, and before you batter the bolt with the hammer, just place a jack under the bolt to be taken out and tighten up on it. Then place a large nut over the head of the bolt and hit it a few good blows with the coal pick or a heavy hammer. If it still refuses to come out, get a shovelful of live coals from the fire-box and place the point of the shovel against the side of the rod at the point where the stuck bolt is and push the fire so it will cause the metal to expand around the bolt, or you can get some oily waste and wrap it around and set fire to it. (It will do as well.) Then when it has heated a little, hit a few good blows on top of the big nut, and nine times out of ten the sticky one will start.

RELIEVING A HOT DRIVING BOX.

Make a block that will just fit between the frame and the bottom of the saddle. Then when running, the weight that should rest on top of that box will a portion of the time be carried on top of the frame. If the box is very hot, run that wheel up on a wedge and put a block between the saddle and the frame that will hold the weight off the box altogether. This will often allow you to run faster than you otherwise could and still do no damage to the bearings.

BROKEN TRANSMISSION BAR OR HANGER.

In disconnecting for a broken transmission bar, all broken parts should be removed. Cover the ports with the valve, disconnect the valve stem and clamp securely. Should the transmission bar hanger break, block the link solid on the top and bottom at a point of cut-off that will enable the engine to handle the train over the division, as shown in Fig. 45.

FRICTION.

The rubbing together of any two surfaces constitutes friction and produces heat. The amount of friction produced is determined by the resistance between the two bodies in contact, which opposes the sliding of one upon the other; the pressure of one body bearing upon the other; the nature of the material or materials in contact, or the nature and lubricating properties of the interposing lubricant, speed and temperatures are also determining factors.

The interposing of a thin layer or coating of lubricant, so that the two surfaces do not come in actual contact with each other, lessens the friction.

KEYING UP A DRAW STRAP, FORWARD END OF MAIN ROD.

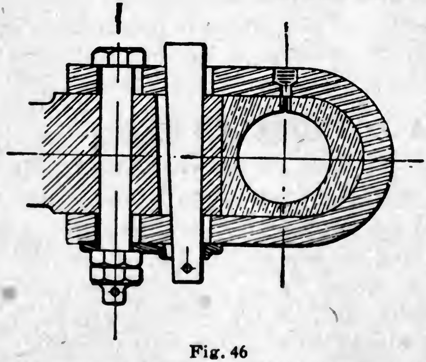


Fig. 46
Draw Strap for Forward End of Main Rod

A draw strap is used on the forward end of main rods on some classes of engines, and the keys go through the main rod and strap, instead of being placed between the end of the rod and the brass. The bolt is a good slip fit in the rod, but the bolt hole in the strap is slotted and you have to loosen the bolt before you can drive

the key. This arrangement shortens, instead of lengthens, the front end of the rod. Observe the construction shown in Fig. 46.

The writer has known of cases where engineers have reported front end of rod brasses filed when this kind of strap was used, because they were not familiar with it, and did not loosen the bolt before trying to drive the key.

ENGINE OUT OF QUARTER.

If the drivers on a locomotive were not quartered properly, it would cause the engine to ride hard at high speeds. The engine would have a jerky motion, very similar to the motion of an engine that is not properly counterbalanced, but with the following difference: The engine not properly counterbalanced has more of an up and down jerk. An engine out of quarter has a fore and aft jerk, and on a wet or slippery rail gives one the impression that the engine is slipping when shut off. At slow speeds the engine seems to hunch up and then let go with a jerk when passing over the centers. An engine very much out of quarter is liable to break a rod or crank pin, and is not a very safe proposition to run.

ANGULARITY OF MAIN ROD.

The meaning of the angularity of the main rod is the angle it forms in relation to the center line of motion when the crank pin is on either quarter, as, for instance, referring to Fig. 47, the line A A drawn through

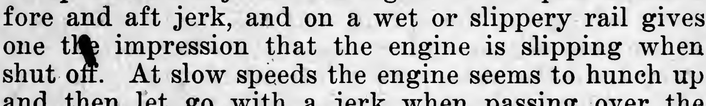


Fig. 47

the center of the cylinder and the center of the main driving axle, is called the center line of motion. The circle B represents the path of the crank pin on either top or bottom quarter, C or D, and assuming the point

E as the crosshead connections, you will note that a line drawn from the crank pin connection to the crosshead conection of the main rod forms the hypotenuse of a right angle triangle, the base line of which is represented by the lines A A and the perpendicular by line C D.

HARD GREASE IN DRIVING CELLARS.

Where engines are equipped with hard grease in the driving box cellars, the engineer can tell whether there is grease enough in the cellar to make the trip by the indicators which are fastened to the follower on the bottom of the cellar, and should the cellar need filling on the road, it can be done by removing the plate on the side of the cellar, pulling down the indicator, which will compress the spring, then filling the cellar with grease. Be sure you get the grease between the plate on top of the spring and the perforated plate. If you haven't enough grease to fill the cellar, take some from the other cellars, or put in what you have and put hard soap on top of it, and it will run O. K.

HOW AND WHEN TO SET UP WEDGES.

When setting up wedges, place the engine on straight level track, under steam (for the reason that parts of the frame lie against the fire-box and expand when heated and are longer than when the engine is cold). If the wedges are to be set up all around, place the engine on the top forward eighth on the right side. This will bring the engine on the left side on the top back eighth. Block the engine truck wheels ahead, put the reverse lever in the forward motion, and open the throttle a little. This will admit steam back of both pistons, and pull all the driving boxes up against the dead wedge I, as shown in Fig. 48, so that all the wedges can be set up without again moving the engine. Loosen the jamb nut 2, also the wedge bolt 3, after which wedge 4 should be pried up with a short bar. On an eight wheeled engine the wedge on the main driving boxes should be set up snugly, and then pulled

down about one-sixteenth of an inch, or until the wedge is free between the box and jaw, and the other wedges

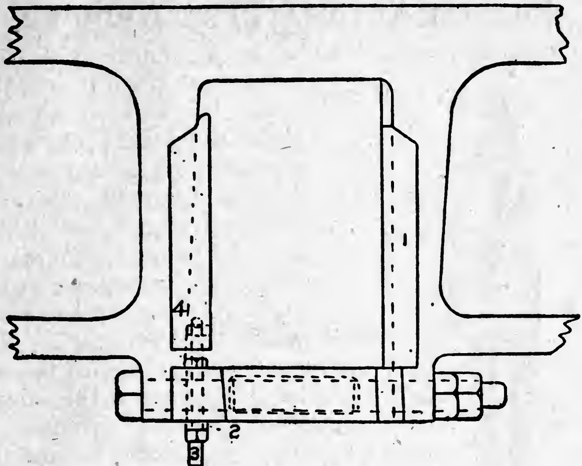


Fig. 48

should be pulled down about one-eighth of an inch, which will give a free movement of the boxes. On ten wheeled engines the front and back wedges should be pulled down about one-eighth of an inch and the main wedges about one-sixteenth of an inch. Then wedge bolts 3 should be adjusted so as to hold wedge 4 in its proper position and jamb nut 2 tightened.

If the wedges are set up too tight and the box sticks, it will cause the engine to ride hard, giving her an up and down motion, and will also cause driving boxes to run hot.

To Pull Down a Stuck Wedge.—Where stuck solid, to pull the wedge down, loosen jamb nut 2 and tighten up on wedge bolt 3, or pry the wedge down. You can also often bring them down by running the engine wheel where the stuck one is over a coal pick or a big nut placed on the rail.

When to Report Lined Down.—If, when the wedge is up against the top frame and there is still lost motion

between the wedge and the box, it should be reported lined down.

GOLLMAR AUTOMATIC BELL-RINGER.

There are several so-called automatic bell-ringers in use on the different railroads, but as they all are on about the same plan, whether operated by compressed air or steam, we will take up the Gollmar ringer, as it is the one in most general use. (Fig. 49 shows an interior view of the Gollmar automatic bell ringer.) There are two openings in the cylinder, the upper A the inlet, the lower B the exhaust port. Air pressure is admitted through opening A. The operation of valve 43, through which a hole is drilled, admits the pressure under the single acting piston 39, which has a stroke of 1¼ inches. When at its extreme travel, crank 31 has a stroke of 4 inches. The connecting rod is in two sections, 35 and 36, which allows crank 31 to make a complete revolution without causing piston 39 to move.

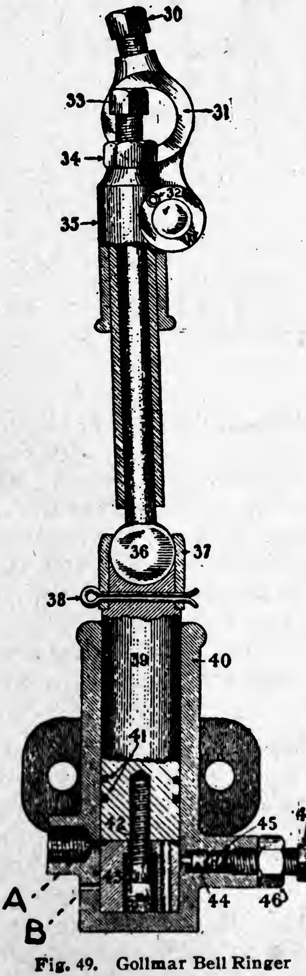


Fig. 49. Gollmar Bell Ringer

After the ringer is started, piston 39 will be driven upward, making the bell swing. Valve stem 42 will raise valve 43, closing the inlet port and using the pressure expansively by travel-

ing the length of the lap before it opens the exhaust port. The bell, having received an impulse, will continue its motion after piston 39 has reached the upper end of its stroke, the crank box 35, sliding on rod 36. The impulse which the bell received, being expended, it will return to its normal position by its own weight. The governor bolt 33 will strike the end of rod 36, which will force piston 39 downward, coming in direct contact with valve 43, and closing the exhaust port and opening the inlet port, after cushioning on the pressure remaining under piston 39, after the exhaust is closed. It will be noted that valve 43 is operated only at the termination of the piston stroke.

BELL RINGER DEFECTS.

When air is admitted to the bell ringer and the bell fails to start, it may be caused by the admission port being stopped up, the valve not having sufficient lift. Crank 31 may be on the dead center, which would prevent piston 39 from being forced upward and exerting its power on the bell. Packing ring 41 may be broken, which would allow the air to escape to the atmosphere as fast as it is admitted to the cylinder. Not enough or too great a lift between the upper piston 39 and lower valve 43. The bell crank may be loose on the shaft, or the parts may not be properly adjusted. Should the piston rise and fall a number of times during the stroke of the bell, it is caused by badly worn packing rings 41, which allows piston 39 to drop, and striking the lower valve, causes it to move down, and this movement again admits air to piston 39 before the bell has returned to its normal position. Should the bell continue to make complete revolutions when in operation, it would indicate improper adjustment of the governor. To remedy this, slack off on governor bolt 33 until the bell will make its stroke without revolving. Then tighten jamb nut 34.

When air is admitted to the bell ringer and there is not enough power to move the bell upward, slack off on jamb nut 34, and screw down on governor bolt 33.

This will lengthen the rod, and if it is not enough to cause the bell to move, it will lengthen valve stem 42, and this will give piston 39 more power to lift the bell before the air supply is cut off.

Adjustment.—The bell ringer can be adjusted to use pressure in proportion to the stroke required. This is done by means of valve stem 42, which is secured in its various positions by a pin. No change in the length of the connecting rod is required in changing the adjustment. The valve adjuster 44 and spring 45 are adjusted in such a manner as to keep valve 43 in contact with the side of the cylinder in which the inlet and exhaust ports are placed, so that there can be no leakage from one to the other. Thus a positive cut-off is assured.

THE LEACH AIR SANDER.

Three or four different air sanders are now in use upon locomotives, but as they all work on similar principles, we will take up the Leach sander, as it is the one in most general use, and explain its method of application and operation. This sander is intended to reduce to a minimum the evils due to sanding the track, for preventing the slipping of driving wheels. A sand trap or pocket, in which is an air nozzle, one trap being provided for each sand pipe and attached to the outside of the sand box, that it may be easily inspected, for this is the main feature of this device. The trap receives its supply of sand through an auxiliary passage, which is normally open, and delivers it into the sand pipe as required by means of the air blast. This arrangement does not interfere with the sand lever and valves, which are usually retained for emergency use. Suitable arrangements are provided in the trap for relieving the wear of the sand blast and also for removing stones and other foreign matter that may lodge there. The compressed air used is taken from the air brake pipe, which leads from the main reservoir to the engineer's brake valve, the pipe conveying the air to the

sand box being placed wherever possible under the boiler jacket in order to heat the air. The feed valve, which regulates the air pressure, and thereby the sand delivery, is a small globe valve having a fine thread on the stem, and with the angle of the valve set nearly parallel with the stem. This allows a very fine adjustment, as a considerable movement of the valve wheel is necessary in order to secure a perceptible opening of the valve. This fine adjustment of the feed valve is an important feature, as a pressure of but two to five pounds at the air nozzle is required for light feeding. and a heavier pressure would only waste air and sand, which should be avoided. In order to prevent the feed valve being forgotten, and thereby left open longer than needed, a telltale attachment is provided in the valve wheel, which sounds a warning whenever the valve is opened for sanding, unless prevented by the operator's hand. If the hand is removed the feed continues and the warning sounds until the hand is replaced or the valve closed.

STEAM GAUGES AND SAFETY VALVES

Description of a Steam Gauge.—Locomotive steam gauges are usually of the Bourdon type, as shown in Fig. 50. The essential parts are a brass or copper tube *a* of elliptical section bent in the form of a horseshoe or circle, and the toothed quadrant *f*, and small pinion *g*, by means of which the motion of the tube *a* is transmitted to the pointer *P*. The end *b* of the tube *a* is fastened to the casting *C*, and is held stationary. The other end is closed by cap *d*, and is free to move. This cap is connected to the quadrant *f* by the rod *e*, the rod meshing with the pinion *g*. This pinion is fixed on the same spindle as the pointer *P*, and the quadrant *f* is pivoted at *m*. Therefore, if the end of the tube at *d* moves, the movement will be transmitted to the pointer *P* through the rod *e*, quadrant *f* and pinion *g*. The boiler connection is made at *k*, and when pressure is admitted to the gauge it passes up *i* and enters tube *a*. This tube

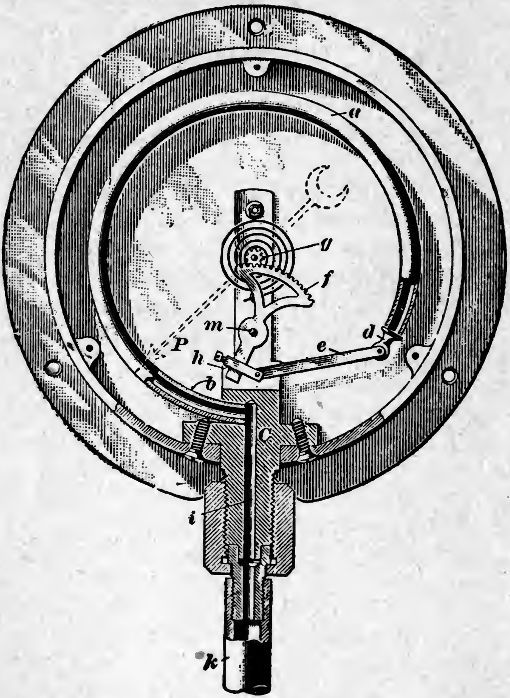


Fig. 50. Steam Gauge

is elliptical in section and the pressure tends to make it circular, the result of this being that the tube *a* straightens out somewhat and the free end *d* moves outward away from the stationary end *b*. This movement in being transmitted to the gauge pointer, is multiplied by the mechanism used so that a small movement at *d* makes the pointer move through a comparatively large space, thus facilitating the reading. The casting *C* is extended upwards, and the various working parts fitted to it. This arrangement not only gives better results than when the parts are fitted to the back of the case, but it also permits of the case being removed for inspection or repairs.

Steam Gauge Defects.—Steam gauges are seldom affected by defects which interfere with their operation. One of the principal defects is leakage in the pipe leading from the gauge to the boiler, which at times becomes loose at the connection with the steam gauge, permitting the water in the connecting pipe to escape at the leakage, which will allow steam to act directly upon the tubes within the gauge, affecting the elasticity of the tubes to the extent that the gauge will not register correctly, but instead will indicate a higher pressure than the actual pressure within the boiler. This defect can be remedied by tightening up on the connection at the steam gauge. Another defect is a slight leakage in the tubes within the gauge, which causes an accumulation of vapor on the dial that obstructs the view, and another defect which occasionally occurs and causes the gauge to fail to register correctly is the stopping or clogging up of the steam valve connection at the boiler. This can only be remedied when there is no pressure on the boiler, and if it occurs while the engine is on the road, the engineer must be governed by the safety valve and the operation of the engine.

SAFETY VALVES.

The three forms of locomotive safety valves herewith illustrated in Fig. 51 are the pop valves in most general use upon American locomotives. I will give a description of each form. They are all three good, reliable safety valves.

Description of the Crosby Valve.—The valve proper B B rests upon two flat annular seats V V and W W on the same plane and is held down against the pressure of steam by the spiral spring S. The tension of this spring is obtained by screwing down the threaded bolt L at the top of the cylinder K. The area contained between the seats V and W is what the steam pressure acts upon ordinarily to overcome the resistance of the spring. The area contained within the smaller seat W W is not acted upon until the valve opens. The large seat V V is formed on the upper edge of the shell or body of the valve A. The smaller seat W W is formed on the upper edge of a cylindrical chamber or well C C, which is situated in the center of the shell or body of the valve, and is held in its place by arms D D, radiating horizontally and connecting it with the body or shell of the valve. These arms have passages E E for the escape of the steam or other fluid from the well into the air. When the valve is open this well is deepened so as to allow the wings X X of the valve proper to project down into it far enough to act as guides, and the flange G is for the purpose of modifying the size of the passage E E and for turning upward the steam issuing therefrom.

Action of the Valve When Working Under Steam.—When the pressure under the valve is about one pound of the maximum pressure required, the valve opens slightly and the steam escapes through the outer seat into the cylinder and thence into the air. The steam also enters through the inner seat into the well and thence through the passage in the arms to the air. When pressure in the boiler attains the maximum point, the valve rises higher and the steam is admitted into

the well faster than it can escape through the passage in the arms, and its pressure rapidly accumulates under the inner seat. This pressure, thus acting upon an additional area, overcomes the increasing resistance of the spring and forces the valve wide open, thereby quickly relieving the boiler. When the pressure within the boiler is lessened the flow of steam into the well also is lessened and the pressure therein diminishes. The valve gradually settles down. This action continues until the area of the opening in the well is less than the apertures in the arms and the valve promptly closes.

DIRECTIONS FOR CROSBY VALVES.

Setting.—Screw the head bolt, which compresses the spring, up for diminishing, or down for increasing, the pressure, until the valve opens at the pressure desired, as indicated by the steam gauges. Secure the head bolt in this position by means of the lock nut. For regulating escaping steam, turn the screw ring G up for increasing, or down for decreasing it.

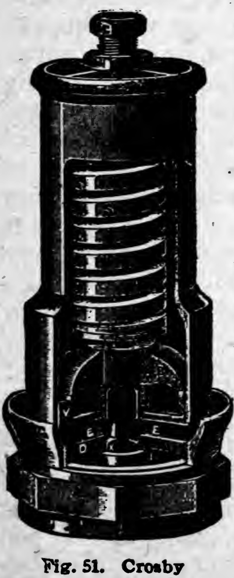


Fig. 51. Crosby

Caution.—Care should be taken that no red lead chips are in the pipes or couplings when connecting the valve with the boiler. Never make a direct connection by screwing a taper thread into the valve, but make the joint with the valve by the shoulder.

Repairing.—This valve, having flat seats on the same plane, is very easily made tight if it leaks, as follows, viz: With an ordinary lathe slightly turn off the ordinary concentric seats of the valve and valve shell or base respectively, being careful that this is done in the same

plane and perpendicular to the axis of the valve. If no lathe is at hand, then grind the valve proper on a perfectly flat surface of iron or steel until its two bearings are exactly on a plane and with good smooth surfaces. Then take the shell and grind its surface in exactly the same manner. Wash both parts in water and put together, and the valve will be found right. To ascertain when the bearings are in the same plane, use a good steel straight edge. Do not grind the valve to its seat in the shell by grinding them together, but grind each part separately, as above stated.

MEADY MUFFLED SAFETY VALVE.

The illustration (Fig. 51) of the Meady muffled locomotive safety valve shows its internal construction.

Fig. 51. Meady

It will be observed that the valve proper projects upward through the perforated casing of the valve, enclosing within it the spring which holds it to its seat, and the upper or outward side of the valve is open to the air at all times so that when the valve is discharging it is free from any pressure of the outgoing steam, which escapes through the perforated casing into the open air without a disturbing noise. By this design there is no back pressure on the valve, and its component parts so co-operate that the valve rises when it opens to a greater height than is usual in valves of this character. For a tension of the spring and the adjustment of the parts, means are conveniently arranged and provided in size and utility. It is believed, to afford all the advantages which are demanded, and to meet all the requirements of an exacting railroad service.

Directions for Meady Muffled Valve.—It should never be meddled with unless it becomes necessary to re-set it. In such cases, first loosen or remove the acorn check nut above the spring bolt; then, holding with a wrench the hexagonal top of the valve, with another wrench turn the spring bolt downward to increase, and upward to decrease the pressure until the valve opens at the desired point, as indicated by the steam gauge. To modify the loss of pressure in blowing, slightly withdraw the screw bolt in the base of the valve until it ceases to engage with the ring encircling the valve. Then, with any pointed instrument inserted into the small opening near the screw bolt, turn the ring downward for diminishing, and upward for increasing the loss.

DESCRIPTION OF THE KUNKLE POP VALVE.

Our illustration (Fig. 51) shows the interior construction of this form of safety pop valve. It will be seen that the formation of the main valve is entirely different from the other two forms of pop valves herein described. It is a cup valve and extends away below the seat, its seat being formed in its top flange, as shown. The cup valve is held to its seat from its lowermost position by a helical spring; the spring, in turn, is held in a central position and adjusted by a stem extending down through the center of the pop. It will be noticed this stem has no head and can be adjusted only by use of a hollow pin wrench. This pre-

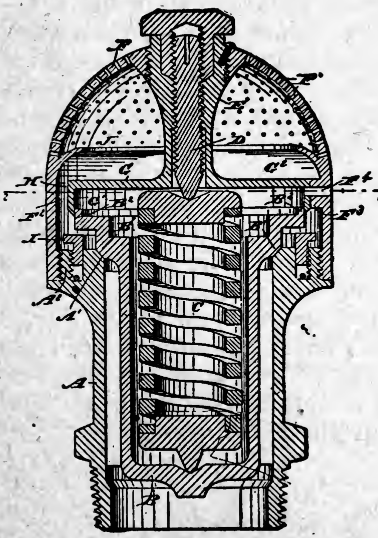


Fig. 51. Kunkle

vents tampering with the pop after it has once been adjusted to the required pressure. The pop valve is also provided with a disc, which can be adjusted from the outside, a slot being cut in the outside shell for this purpose. It will be seen the semi-spherical cap is perforated and has a curved lip formed on the inside of the cap above the inlet port to direct the steam to the middle of the pop.

HOW TO SET LOCOMOTIVE POP VALVES.

Every locomotive boiler is, or should be, provided with two safety pop valves. (Not necessarily the same make.) This is a safeguard in event either pop should fail to work. One pop is usually set to carry a few pounds more pressure than the other. However, one good pop is considered sufficient to relieve any ordinary boiler. Test each pop valve separately by tightening down the spring on the other pop, and ascertain which is the most sensitive. Whichever one loses the least steam during a discharge should be used. By this I mean when the pop springs are properly adjusted it should be the first to relieve the boiler pressure, but it is necessary to set the other one first, which can be done by screwing down the spring on the best pop and then the other one at a pressure of two or three pounds more than working pressure. If either pop loses too much steam during a discharge it may be regulated by adjusting the disc until the discharge is normal. Pops are sometimes set by steam gauge testers, but more frequently under steam pressure. Some safety valves are so constructed that the spring can only be adjusted with a hollow wrench. These wrenches are not furnished to the engine, so it is impossible for a road man to tamper with the pop, grade or no grade.

INJECTORS

THEORY OF THE INJECTOR'S ACTION.

There is a wide diversity of opinion regarding the theory of the injector's working, the generally accepted theory being that the high velocity of the steam as it issues from the boiler strikes the column of water and, mingling with it, carries it along into the boiler. It forces its way into the body of water in the boiler, which, though under the same pressure as the steam which operates the injector, is a passive body and cannot resist the velocity of the inflowing water. This is, in brief, the velocity theory, which is the one generally accepted by engineers and professors, and which can be enlarged upon as much as desired by the use of figures showing kinetic energy, etc., if desired. There are a few, however, and among them the makers of well known injectors, who do not agree with this theory, and who, in the opinion of the writer, have good grounds for their opposition. They argue that, if the velocity theory was correct, injectors could be made with the steam and discharge tube of the same diameter (or with the steam tube possibly a trifle larger to allow for friction of steam before reaching the water), as the velocity would be there just the same to force the water back to the boiler. In reality, an injector will not work under these conditions, but the area of the steam tube must be considerably in excess of the area of discharge tube or the injector does not do its work, and this difference in area will be found to vary as the difference between the steam pressure and the pressure the injector forces against increases. Where an injector forces water directly into the boiler, which supplies the steam, the pressure per square inch of the steam leaving the discharge tube need be but a little in excess of boiler pressure, enough to lift the check valve disc and allow water to flow in. The steam flowing into the mouth of the steam tube is condensed by the water, and the water heated somewhat. This

mass of water practically forms a piston against which the steam acts, and as the area (and consequently the total pressure) here is greater than the area at the throat of the discharge tube, the water is forced into the boiler. When, however, the steam at the injector is of lower pressure (from being wire-drawn through quite a long pipe, when, as is sometimes the case, the injector is at some distance from the boiler), the area of steam tube must be larger than in the first case to overcome the increase of pressure it must force against as compared with the lower initial pressure at steam tube. For boiler testing injectors used in many railroad shops for making a pressure test with hot water, the tubes must be specially made to force against the pressure it is desired to use in testing the boiler. In some cases this is four times the initial pressure, and the writer has seen a testing injector work against about five times its initial pressure. This necessitates a steam tube having a larger area than the injector for ordinary work, the same as a steam pump requires a larger steam cylinder to force against a high pressure than a low one. If the velocity theory was the correct one, it would seem as though the pressure per square inch at the discharge tube would be practically independent of the area of the steam tube as long as the steam tube was as large as the discharge tube. When an injector is used to force against a gauge (for testing), as into a boiler already full, the velocity seems to be lacking, the only water escaping at the overflow being little more than the amount of condensed steam. This seems to the writer is additional argument in favor of the pressure rather than the velocity theory. Exhaust injectors are limited to low pressure and cannot be used for much over sixty-five or seventy pounds, as the initial pressure is usually a little over fifteen pounds. The nozzle would have to be made to correspond, and it will be found that the area of the steam nozzle is greatly in excess of the discharge nozzle. The experience of those who oppose the generally accepted theory is that the injector's action may be likened to

that of a steam pump, the forcing of water being dependent on the excess of total pressure in the steam tube over that opposing the flow of water from the discharge tube. This seems to be proven by the necessity of enlarging the area of the steam tube (and, of course, adding to the total pressure) when the pressure against discharge end begins to materially exceed the steam pressure. This can readily be illustrated by taking the outline of a steam pump and drawing the injector tubes over it, retaining the same dimensions and proportions. The diameters of the tubes are taken at their throat or smallest part, the tapers and curves being used to aid in the flow of water and steam, but in common practice, throats are considered in calculating pressures. The shape of the nozzle or tube affects the amount of water passing through, as can be studied in any work on hydraulics or hydromechanics.

INDUCED CURRENTS.

While the theory of an injector's action is generally accepted to be that of induced currents and is no doubt the principal cause of the injector's action, it will be found that the formation of the injector's tubes and nozzle have much to do with the successful operation of an injector. It is a well known fact that a current of any kind has a tendency to induce a movement in the same direction of any body it passes or touches. Thus, a passing train will draw articles in its path. For the same reason, wind will cause a ripple or produce waves when passing over a body of water. Under a given presure, the velocity of escaping steam is much greater than that of water. For example, if a boiler with ninety pounds pressure had two holes cut in it simultaneously, one above and one below the water line, the velocity of escaping steam would be about nine times greater than that of water. Water being a solidity, will not penetrate the atmosphere as rapidly as steam, which is only a vapor. Therefore, the steam, which has the greatest velocity, meeting the water in the injector, induces its movement, and the

water, which is a solidity, strikes the check valve with sufficient force to raise the valve, and its momentum keeps the check valve open, but the temperature of the steam is greatly reduced before re-entering the boiler. Injectors do not always begin working when the throttle is first opened, for that reason an overflow is supplied where the water can escape until the required momentum is attained. Blowers, steam siphons, steam jets, and many other instruments, are operated upon the same principle.

VARIOUS FORMS OF INJECTORS.

Injectors may be divided into several classes, the principal ones being single sets of tubes, double sets of tubes, fixed tubes, open overflow, closed overflow, adjustable and self-adjusting tubes, and these can again be sub-divided into re-starting, automatic, non-lifting and lifting. A closed overflow is one that is closed by hand after the injector is started and remains so until again opened by hand. An open overflow is one that automatically opens when water or steam flows through the injector, but closes (usually) by gravity, though in some cases by a light spring when the injector gets to work. Its only use in overflow injectors is to prevent the air being drawn in, slightly cooling the water and making a disagreeable noise. This feature is used by some engineers to put boiler fluid into their boilers without dumping it into the water supply tank. By simply removing the overflow valve disc and placing the overflow nozzle in a shallow dish holding the fluid, the fluid will be drawn into the injector and forced into the boiler without any difficulty. The open overflow has the advantage of showing at once when the injector breaks or stops working. There are cases in locomotive work, however, where the overflow is piped so it can not be seen by the engineer, thus entirely destroying its advantage over the closed overflow. The use of the fixed nozzle, or non-anjustable tube, injectors is constantly increasing, as shown by the number of re-starting and

other fixed tube injectors now on the market. The fixed nozzle or tube type is somewhat different. There is no way of regulating the water supply except by the water valve in the pipe (few of the leading injectors having special valves for this purpose now), but, owing to the construction and proportion of the tubes, this is seldom necessary, as they will handle quite a wide range of both water and steam without difficulty. With extreme water pressure, it may be necessary to throttle it, but this seldom occurs, the combined action of the two jets, the central one and the auxiliary annular jet, giving a particularly flexible action, if such a term can be used. They will not, however, handle as wide a range as the adjustable tube injector and cannot, from the nature of things, notwithstanding the various claims of some makers. With this type of injector the overflow is usually situated in an overflow pipe at any convenient point between the injector and boiler. This is often controlled by an ordinary globe valve, which must be open before starting the injector, and the outlet of this should be visible, although the sound will help greatly after becoming accustomed to it.

CARE OF AN INJECTOR.

Many a fire has been killed, and many an engine towed in, owing to the engineer's lack of knowledge of the injector. Every man who is entrusted with the care of an injector should thoroughly understand its philosophy. If he does not, he cannot expect to operate it successfully at all times. It is true the difficulties connected with the successful operation of the injector have been greatly lessened by the use of the latest improved injectors. Nevertheless, every prudent engineer or thoughtful machinist makes it an object of ambition to study the principle of the injector's action and its construction, in order to enable him to locate any defects in its action. To preserve a good working injector, all pipes and joints should be kept perfectly tight, and all stems and glands well packed,

as the admission of air into the injector will affect its action. The air mixing with the water, has a tendency to decrease the speed of the water by impairing its solidity and making it a semi-elastic body. Such a defect can usually be noticed by a bubbling sound at the check valve. The water not being a solid, compact body, small leaks neglected will eventually cause the injector to break or not work at all. All pipes leading to the injector should be carefully examined for leaks, particularly the feed pipe, above water level. Leaks affect lifting injectors most, as it prevents the steam jet from forming a vacuum. The object of the steam jet on all lifting injectors is to force all the air out of the injector. The atmospheric pressure on the water in the tank then forces the water up the feed pipe and into the injector, when the steam can be turned on full force. Most all improved injectors have a small priming valve attached to the steam valve so the injector will be primed before the steam valve can be fully opened. When an injector will not prime, first see that you have sufficient water in the tank, and if in the winter see that the tank is not frozen up so as to prevent the admission of air. Next see that the overflow or hose is not stopped up or that the check is not stuck. When a check leaks or sediment gets on the seat it sometimes prevents priming. Give the check or branch pipe one or two slight taps and it may start, but do not batter it out of shape. If you have a bad check, report it. If the injector sucks air, or if the nozzles are out of line it will not prime. If it primes all right, but breaks, it indicates that it is not receiving sufficient water. Examine the hose. If it is all right, disconnect branch pipe from the check and clean it out, or the trouble may be in the nozzle. If it primes, but will not start and steam and water both escape at the overflow, increase the steam pressure or reduce the water supply. (The steam throttle at the boiler should once be regulated and then marked so as to prevent further trouble with it). In this case the check valve may not have sufficient lift. Some in-

jectors have an adjustable combining tube which adjusts itself to the volume of steam and water passing through it. If this tube is prevented from working freely by either grit or sand, the injector will break. Clean out the hose frequently, for cinders and dirt choke up the strainer very quickly. A frequent cause of annoyance with injectors is a leaky check valve which blows back and heats the injector so that it will not work. In such a case, open the water valve and overflow and turn the primer full on and try to fill the injector with cold water, letting it run a few minutes, when the injector will probably start. Such a check should be reported at the first opportunity. Perhaps the most frequent cause of the injector refusing to work is in calcareous districts where it becomes choked with lime. This is easily discovered, as its force will gradually diminish until it refuses to work under low pressure, another defect is a loose nozzle which will work best with a high pressure of steam. This may be discovered by removing the frost plug and the main ram. When nozzles are worn too large the injector will refuse to work, and they should be replaced with new ones. In winter all injector pipes should be supplied with drain cocks at their lowest point and kept open when not in use to prevent the pipes from freezing. Injectors should be oiled regularly, but lard oil should not be used, as it has a tendency to make the water in the boiler foam. When this occurs change the water in the boiler and tank at the first opportunity.

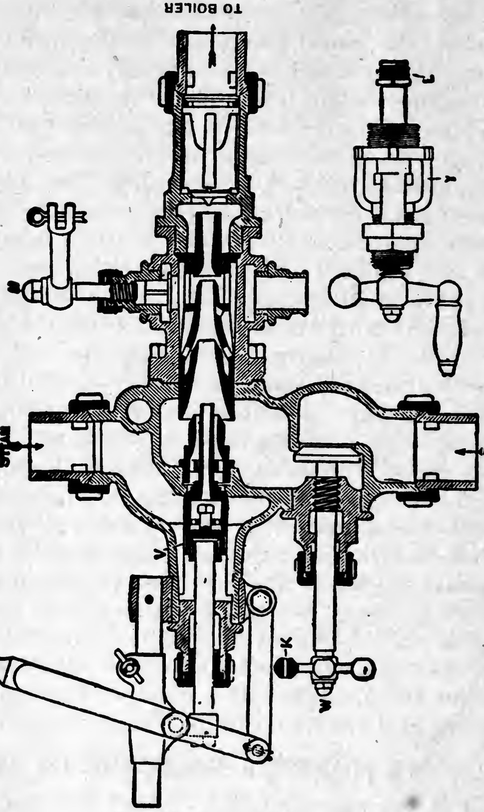
THE MONITOR INJECTOR OF 1888.

Since the introduction of the Monitor injector in 1880, they have been classed among the most efficient, reliable and practical injectors in use, and they are so extensively used that no introduction is necessary. The cut shows a No. 9 Monitor of 1888.

HOW TO OPERATE THE 1888 MONITOR.

To Start—Open the steam valve one-quarter of a turn to lift the water. Pull the lever back until the

resistance of the main steam valve is felt (if a lever motion), to lift the water. When water runs from the overflow, open steam valve until overflow ceases. Do



No. 9 Monitor of 1888

not increase the steam supply after overflow has ceased. Regulate for quantity with water valve W. (See cut).

To Stop—Close the steam valve.

To grade injector—Throttle water by valve W. If this is not sufficient, reduce the steam by pushing in lever handle about half way, and if a screw motion, by screwing in the steam spindle about half way.

To use as a heater—Close valve H and pull out lever all the way; and in case of screw motion, open valve full. At all times valve H must be kept open. The heater cock can be worked from the cab by means of an extension rod. The hole in the knob K of water valve W indicates the position of the water valve. One turn of the handle fully opens or entirely closes the water passage. In either case, the knob with hole in should be in an upright position. Intermediate position of the knob K indicates corresponding openings in the water passages.

CAUSES WHICH PREVENT INJECTORS FROM WORKING.

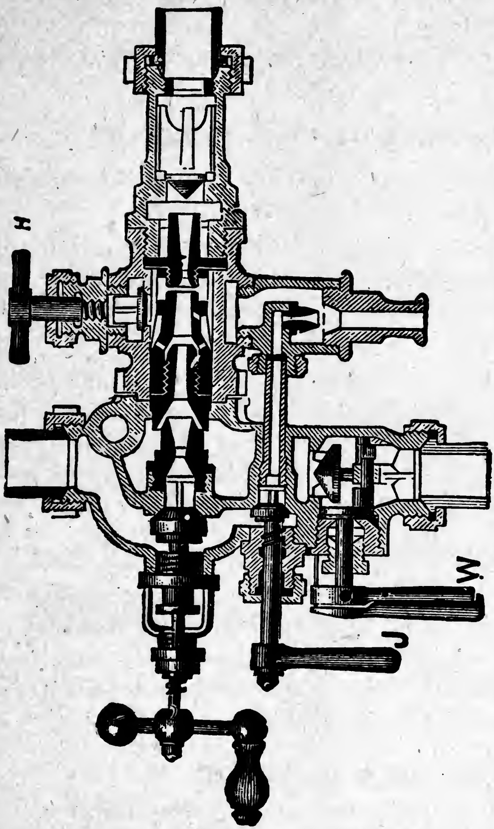
On this subject there are principally two conditions to be considered.

First.—The injector refuses to lift promptly or lift at all. This may be caused by leaky joints in the suction pipe, by improperly packed water valve stems, by dirty or clogged up strainers, clogging of the lifting steam passages in the injector, hot suction pipe, etc., etc. In connecting an injector, either when new or when it has been taken down for repairs of some kind, particular care should be exercised in testing the suction pipe for leaks by well known methods. Particular attention should be paid to the strainer. It should be taken out and examined and cleaned before each trip. (An ounce of prevention is often worth a pound of cure.) Cheerfully undergoing a little trouble may be the cause of preventing a great deal of annoyance, anger and expense. Hot suction pipes are usually the result of leaky steam valves or leaky boiler checks. If you notice any leaks in either have them attended to without delay, the longer repairs are put off the more

aggravated will the trouble become and the greater will be the cost of repairs, not taking into consideration the danger of something serious occuring during a run as a result of neglecting timely repairs.

Second.—The injector lifts the water but refuses to force it into the boiler or forces it partly into the boiler and partly through the overflow. This may be caused by insufficient water supply, as a result of improper size of suction pipe, hose or tank valve opening, by clogged up strainer, obstructions in the opening of the boiler check nozzles, (pieces of coal scale from steam pipe, waste, etc.) sticking of the boiler check or of the line check valve of the injector, by insufficient steam supply or wet steam. The pipes of an injector should never be smaller than the sizes called for by the injector connections, more especially the suction pipe and the clear opening of the tank valve. Sharp bends in the pipe work should be avoided as much as possible. The pipes more especially iron pipes, should be thoroughly blown out before connecting up to remove scale and dirt from the pipes. The sticking of the boiler check or of the line check valve is mostly caused by sediment and scale, resulting from bad water. Incrustation of the nozzles by lime deposits around the points of the nozzle will also cause improper action. Generally the effect of bad water may be partly if not wholly eliminated by cleaning the injector frequently and by placing it occasionally into an acid bath. Injectors work best with dry steam, for which reason the steam supply pipe should be attached to the highest point of the boiler. If steam be taken from a fountain to which other steam appliances are connected the volume of cubic contents of the fountain must be large

enough to more than amply supply all appliances connected to the same.



The Standard Monitor Injector

THE STANDARD MONITOR INJECTOR.

The Standard Monitor Injector is perhaps in most general use at the present time. A great point of convenience about this injector is that they can be operated either inside or outside the cab and the valves are easily removed, and the body of the injector being in two sections, the nozzles are easily taken out.

HOW TO OPERATE THE STANDARD MONITOR.

To Start.—Open Jet J (see cut) when water appears at overflow, open steam valve until overflow ceases, then close Jet J. Do not increase steam supply after overflow has ceased.

To Stop.—Close overflow valve.

To Heat Water in Tank.—Close Valve H and open the overflow valve, but the valve H should never be

closed except when the injector is to be used as a heater cock.

Regulate.—For quantity of water needed by Valve W.

ACTIVE PARTS OF THE INJECTOR.

First.—A steam nozzle through which the operating steam from the boiler enters the injector.

Second.—A combining and condensing nozzle in which the steam and feed water meet and in which the steam condenses and transmits its dynamic force to the water.

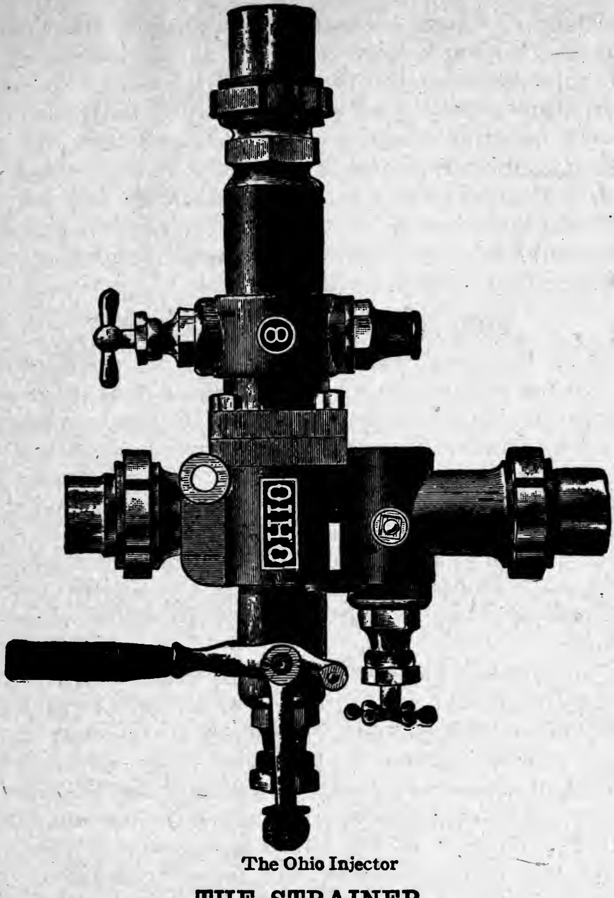
Third.—A delivery nozzle in which the maximum velocity of the combined mixtures of steam and water is attained and subsequently reduced by means of the expanding curves or tapers and increasing cross sections to the velocity and pressure in the boiler pipe.

EXPLANATION OF THE NUMBERS ON THE INJECTOR.

The numbers which may be seen on most all injectors indicate the exact diameter of the smallest orifice of the delivery tube expressed in millimeters, which is equal to .03937 inches.

THE OHIO INJECTOR.

This is a thoroughly modern injector designed to meet the requirements of the present day. It is noted for its simplicity, having fewer parts than most injectors which are arranged in a convenient manner foı repairs. The combining and delivery tubes are both attached to the nose of the injector so that they are easily removed, and the lifting tube, instead of being screwed to the shell, is held in place by the flange joint. Quite a number of these injectors are now in use and they are giving universal satisfaction.



The Ohio Injector

THE STRAINER.

The little conical copper strainers of the feed pipe should be abolished, as they are a nuisance and the cause of more trouble than they get credit for. If a premium had been put upon designing something to readily catch and retain any dirt in such a manner as to materially reduce the water supply, these strainers would undoubtedly receive the first prize. The very fact that they are inside of the pipe is objectionable.

The strainer should be outside of the pipe, either directly below the tank valve or well, or at the end of the feed pipe between the pipe and the hose. The size of the strainer should be such that even if half filled with cinders or other matter it would retain the full pipe capacity. It should also be designed so that it could be readily cleaned at any time, and in a very few minutes. Such strainers can be obtained in the market and their cost would be more than compensated for by avoiding trouble often caused by their absence.

THE HANCOCK INSPIRATOR.

The Hancock inspirator consists of an apparatus for lifting and one for forcing, which feature is common to no other injector. The Hancock inspirator works well under the most severe conditions, either with high or low steam pressure or on lifts up to 25 feet. When taking feed-water under a head, with feed-water at a high temperature, as well as cold water, at all steam pressures and under all conditions, its operation is the same and it does not require any adjustment for variation of pressures. Our illustration shows a sectional view.

The lifting feature consists of a steam nozzle and a combining tube. The throat of the combining tube being much larger than the smallest opening in the steam nozzle enables it to increase or decrease the amount of water as the steam pressure increases or decreases. As steam pressure increases the pressure in the delivery chamber of the lifter is increased. Thus enabling the water to enter the forcer combining tube against the increased pressure of steam from the forcing nozzle. Enabling it to work from high to low pressure without any adjustment of either water or steam supply.

To operate.—To start the Inspirator pull lever 137 back slightly to lift the water (numbers used for this explanation will be found in the illustration). After water is lifted pull it back to the stop. When lever 137 is pulled back slightly, it admits steam to lifter steam

valve 130, through forcer steam valve 126, to lifter steam nozzle 101. The rush of the steam into lifter tube 202 creates a vacuum and causes the water to flow through lifter tube 102, condensing the steam, and out through intermediate overflow valve 121, then through the final overflow valve 117-C in the delivery chamber. The further movement of lever 137 opens forcer steam valve 126, admitting steam to forcer steam nozzle 103, and to forcer combining tube 104, creating a pressure in the delivery chamber sufficient to close intermediate overflow valve 121, and open line check-valve 111. The final overthrow valve 117-C will then be closed and the inspirator in full operation when the lever 137 is drawn back to the stop. When the pin in the wheel of the regulating valve is at the top, the inspirator is delivering its maximum quantity of water. To reduce the supply turn the regulating wheel to the right.

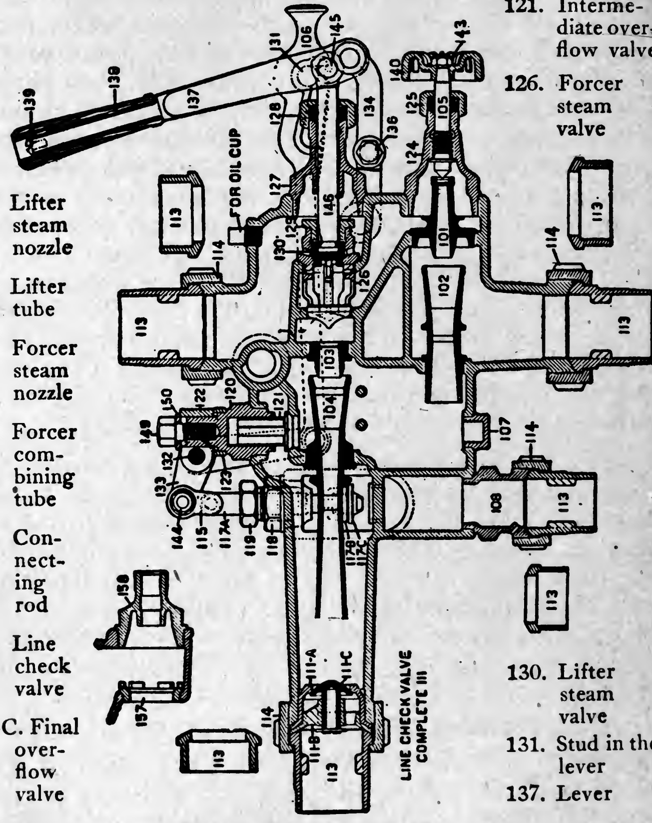
To Use as a Heater.—Lift connecting rod 106 until disengaged from stud 131, then draw back rod to close overflow valve 117-C. Pull lever 137 back to the stop used in lifting. This will generally give all the steam required for a heater. If too much steam flows back into the tank, regulate it by the regulating wheel 134. It is not necessary to close the main steam valve at the boiler. For with the lever 137 in this position all steam blowing back passes through the lifter nozzle.

Not Working Well or Breaks.—Sometimes the inspirator will not work well with the regulating valve open full, but will work when this valve is partially closed. This condition would indicate an insufficient steam supply, and may be due to contracted opening in the valve next to the boiler fountain, or the dry pipe leading to the fountain being too small, and if so should be remedied. Should the inspirator break it may be caused by an insufficient supply of water caused by a restricted opening in the tank valve, small opening in the goose neck leading to the tank, strainer stopped, a kinked or collapsed hose, or leaks in the feed pipe.

NAMES OF OPERATING PARTS.

121. Intermediate overflow valve

126. Forcer steam valve



101. Lifter steam nozzle

102. Lifter tube

103. Forcer steam nozzle

104. Forcer combining tube

106. Connecting rod

111. Line check valve

117-C. Final overflow valve

130. Lifter steam valve

131. Stud in the lever

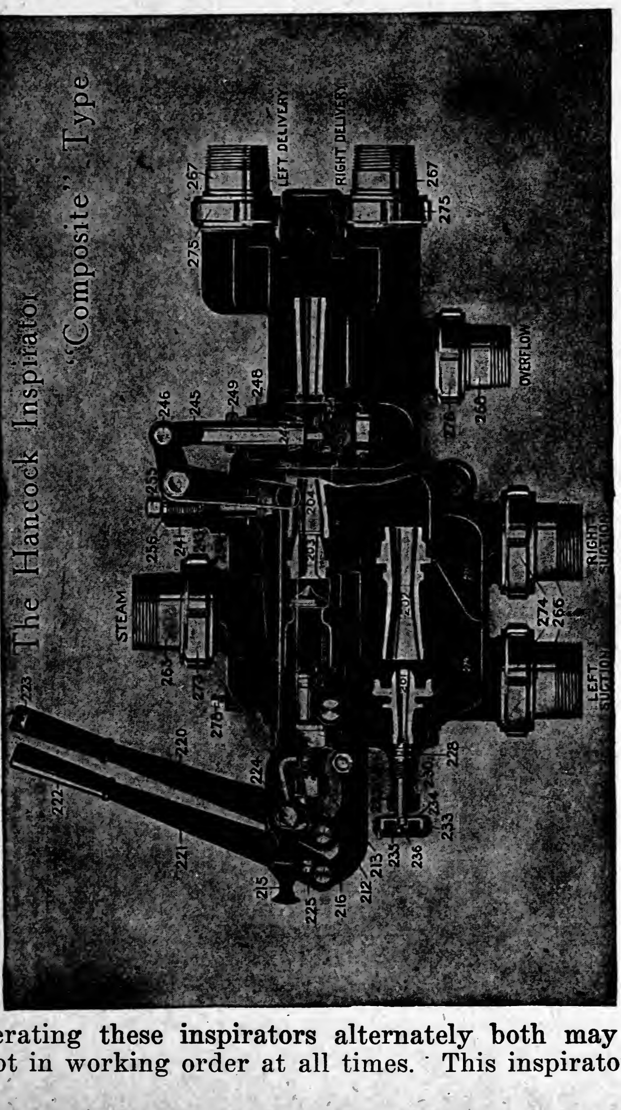
137. Lever

Type A, Hancock Inspirator

THE HANCOCK INSPIRATOR COMPOSITE TYPE.

The Hancock Inspirator Composite Type is a double inspirator consisting of two separate and individual inspirators within one body, and which may be operated separately or simultaneously at will. This instrument fills a long felt demand, as it permits of connecting two inspirators with practically the expense of connecting one, thus giving two independent

ways of feeding the boiler and taking up no more room than the single instrument. By making a practice of



The Hancock Inspirator "Composite" Type

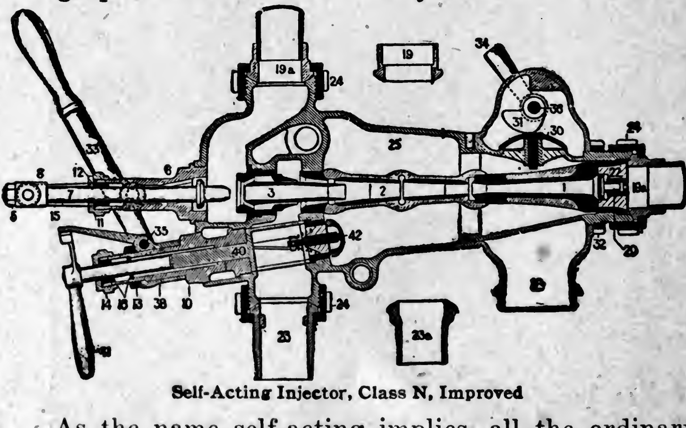
operating these inspirators alternately both may be kept in working order at all times. This inspirator is

so constructed that by removing the delivery end cap the forcing tubes of each inspirator may easily be removed for cleaning or removal. The valve mechanism of each is independent and the capacity of each may be controlled by the regulating valves in the same manner as the type A inspirator.

Operation.—The range and method of operating the Hancock composite inspirator is the same as for the Hancock type A inspirator. When it is desired to operate both inspirators at the same time, start one and after that is working start the other, and they will both work all O. K.

THE SELLERS SELF-ACTING INJECTOR.

Below we give a cut of the Sellers Self-Acting Injector of the Class N improved type. This injector is applicable to all kinds of steam boilers and is a reliable boiler feeder under the severest conditions. The makers claim it will lift the water promptly even when the suction pipe is hot. At ten pounds steam it can lift the water two feet, at thirty pounds five feet, and at high pressure twelve to twenty feet.



Self-Acting Injector, Class N, Improved

As the name self-acting implies, all the ordinary hand adjustments for re-starting or regulating the feed supply to suit changing steam pressures are en-

tirely dispensed with. All adjustments are automatic. It is re-starting. That is, if the water supply is temporarily interrupted, the injector will start automatically as soon as the supply is resumed. It is self-adjusting, requiring no regulation of the water supply to prevent overflow above forty pounds of steam pressure. The minimum capacity is forty per cent of the maximum. The construction is such that the tubes and other parts can easily be taken out for cleaning and repairs, by unscrewing the jamb nut. The waste pipe can then be removed and the body can be passed through a hole in the cab frame. In the improved injector no change has been made in the form of the tubes and nozzles, but the water supply valve has been altered and a graduated lever and index substituted for the regulating hand wheel. Its manipulation when lifting water is very simple.

To Operate.—To start, pull out the lever.

To Stop.—Push in the lever.

Regulate.—Water with the water valve.

To Use as Heater.—Close waste valve and draw out starting lever.

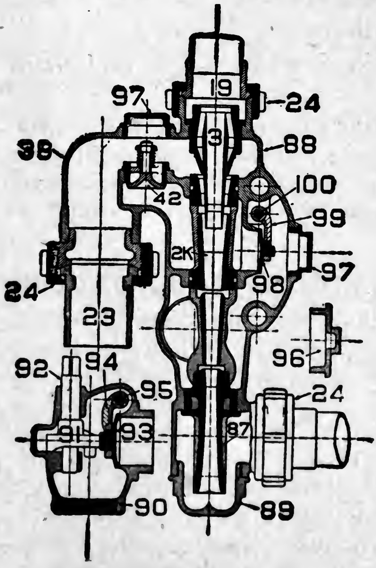
In starting on high lifts and in lifting hot water, pull out starting lever slowly. When it is desired to attach a pipe to the overflow nozzle, the inside diameter of the pipe must not be less than the inside diameter of the nozzle.

SELLERS SELF-ACTING NON-LIFTING INJECTOR.

This injector is applicable to all kinds of steam boilers. It will start promptly, even when the water supply pipe is hot and the capacity increases with the steam pressure from 30 to 225 pounds, using the same set of tubes. It is designed to receive the water supply under a head and should be placed below the running board of the locomotive. It is provided with the Sellers new patent balanced inlet valve. This valve gives an additional inflow of water to the tubes during the operation of the injector, surrounding them with a

bath of cold water direct from the water supply, reducing the formation of scale and largely increasing the capacity at high steam pressure without affecting its action at low steam. All the ordinary hand adjustments for re-starting, or regulating the feed supply to suit changing steam pressure are entirely dispensed with. All adjustments are automatic. It requires no regulation of the tank valve or lazy cock to prevent overflow when the steam pressure falls, and is especially designed for hot water. The construction is such that the tubes and other parts can easily be taken out for cleaning and repairs, by unscrewing the cap at the lower end. The combining and delivery tubes may easily be removed. The overflow valve is closed by a quick acting cam, requiring only a one-half turn of the extension rod.

NAMES OF PARTS OF NON-LIFTING INJECTOR



NUMBER.
2K. Combining tube
3. Steam nozzle
19. Rings for copper pipe
23. Union for iron pipe
24. Coupling nuts
42K. Inlet valve
87. Delivery tube
88. Body.
89. Cap at end of body
90. Waste pipe
91. Cam to close waste valve
92. Cam shaft
93. Waste valve
94. Hinge for 93
95. Pin through 90 and 94
96. Cap opposite 90
97. Caps I over 42 and 98
98. Hot water valves
99. Hinge for 98
100. Pin for 99
101. Caps for pin 100

OPERATION.

Open the overflow water and steam valves. Regulate for quantity with water valves.

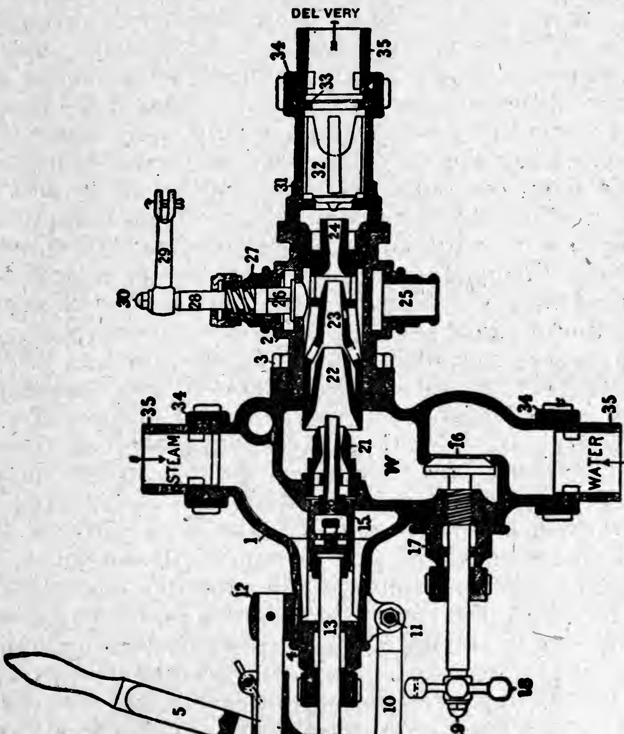
To Use as a Heater.—Close the overflow valve. As the temperature rises towards the limit (105 degrees), the capacity is reduced. On opposite page I give sectional cut with the names of the different parts and their numbers, as shown in the cut.

SINGLE AND DOUBLE TUBE INJECTORS.

Most of the engineers and firemen are familiar with the general principle of an injector, and you all know there are many kinds of varying types, the injector of each make differing from others. It is generally considered only in style of construction, but there is a greater difference in them than mere construction, as I will try to explain in the following article. A lifting and non-lifting injector may both represent but one branch of the injector family. The working principle is the same in each, only the lifting injector is placed higher than the level of the water supply and a starting jet or water lifting mechanism must be supplied to raise the water to the injector before the actual forcing can be started to work, while the non-lifting injector needs no lifting jet, being located lower than the supply tank. The water flows to it whenever the water valve is opened. No doubt, you have often noticed that some injectors work with the overflow closed, never spill a drop of water after the injector goes to work, but the overflow is opened when you shut off the injector, and if the tank is full, sometimes the water continues to siphon out through the overflow, making it necessary to break the injector just before shutting it off, that is, to shut off the water supply before shutting off the main operating lever. This kind of an injector is generally of the double tube type, of which the Hancock inspirator is one of the best representatives. Other injectors of more common and older use in locomotive service are

the single tube type. I will take the Monitor to represent that type, as it is well and favorably known. The single tube injector works with an open overflow, and while working, if the steam pressure falls, or the single tube injector will not energize or combine with all the water coming to it, and there will be a spill of water constantly thrown off at the overflow. Easing off a little with the water valve will stop this and it will again take up the water. Referring to the cut showing the Monitor injector, the boiler pressure is constant in the passage marked steam, and to start the injector handle 5 is drawn out its spindle 13, pulling the lifting valve 14 open, which has been held closed by the pressure of steam against it. When its bottom head (shown just to the right of number 14) strikes the steam valve 15, its resistance will be felt, as it also in greater area has the boiler pressure of steam holding it to its seat. Steam through lifting valve 14 and lifting nozzle 20 will blow through intermediate and condensing nozzles 22 and 23. This will start the production of vacuum in the chamber W. The water valve 16 should be open wide enough to supply the required amount of water which will fill the vacuum, and receiving the energy of the steam from tube 20, will condense the steam, and as a jet of energized water not yet having force enough to open the line check 32, will raise heater cock check (sometimes called overflow valve) and discharge itself at overflow nozzle 25. The presence of water at the overflow indicates that the supply is lifted and the injector ready to be put to work. Draw the handle 5 clear out. The bottom of the lifting valve will pull the steam valve 15 wide open and the heavy volume of steam rushing through it will escape from steam nozzle 21, with force enough that in combining with the water and condensing (changing its form from steam to water). The energy of the water jet is now sufficient to force it through delivery nozzle 24. Open the line and boiler checks and enter the boiler. If the steam pressure is at or close to the pressure at which

the injector is designed to work, it will take up or energize all of its feed water, but if the steam pressure falls (which is the natural effect of an injector supplying water to a boiler), the water valve must be closed off a little or there will be more than the weakened steam pressure can use and the surplus will be forced out through the openings between the tubes 22, 23 and



Monitor Injector of 1888

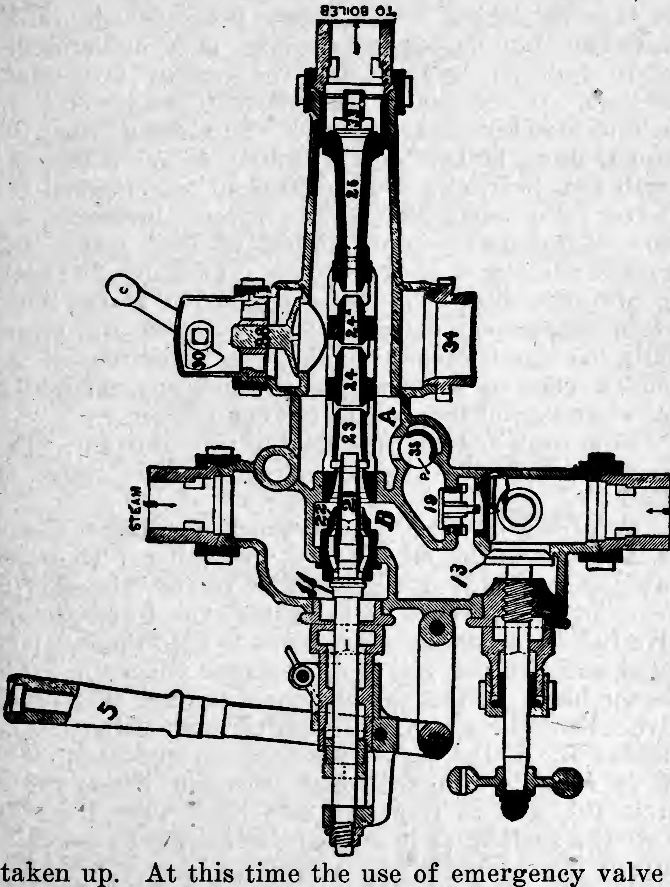
24, raise valve 26 and be discharged at nozzle 25. If the water valve is partly closed, enough so that no

water is wasted, and the steam pressure be increased afterward, the injector will break or cease to work and steam will fly from the overflow and blow back into the tank.

A later improved single tube injector that has a wider range than the older ones of single tube type is the Simplex (a cut of which we give). By wider range is meant the variation of steam pressure or amount of feed water supply within certain limits will not cause waste of water nor breaking of the injector, but it will continue to work with reduced or increased capacity. Another improved feature is that if the water supply is entirely cut off temporarily, as is sometimes the case when the water gets low and swashes around in the tank, while this injector will break, it will at once re-start itself on the return of the supply of water to it. In the cut of the Simplex it will be seen that the lifting and combining action is nearly the same as with the Monitor. The outer tube 22 is the lifter and a slight pull of the handle 5 draws valve 11 from its seat, permitting steam to pass through, lifting tube 22 into the intermediate tube 23 and combining tubes 24 and 24A. The vacuum that formed draws the water into the tubes, through which it is forced and through heater cock check 26 to overflow nozzle 34. Drawing out handle 5 to its limit pulls valve 11 wide open, so that steam will also pass through the large steam nozzle 21 and combine with the water, as explained in connection with the Monitor injector. It will be noted that the steam nozzle is rather large, and at full steam pressure has a capacity for combining with and energizing more water around it above B, but the divided sections of the combining tube offer other points for it to receive water, and if water valve 13 is open wide enough, water will be drawn through inlet valve 19 into chamber A, because a partial vacuum has been formed therein if valve 26 does not leak.

With the maximum steam pressure, there is therefore two different points at which the forcing column

receives its water at B and A. When the steam declines in pressure combining action at the opening in the tubes 23, 24 and 24A gradually ceases until at low steam pressure the water through chamber B only is



The Simplex Injector

taken up. At this time the use of emergency valve 35 may be indicated. If water is only taken through chamber B, there is a void in chamber A, and if inlet valve 19 should leak, a spill of hot water waste from the tubes would pass through the leaky valve and so

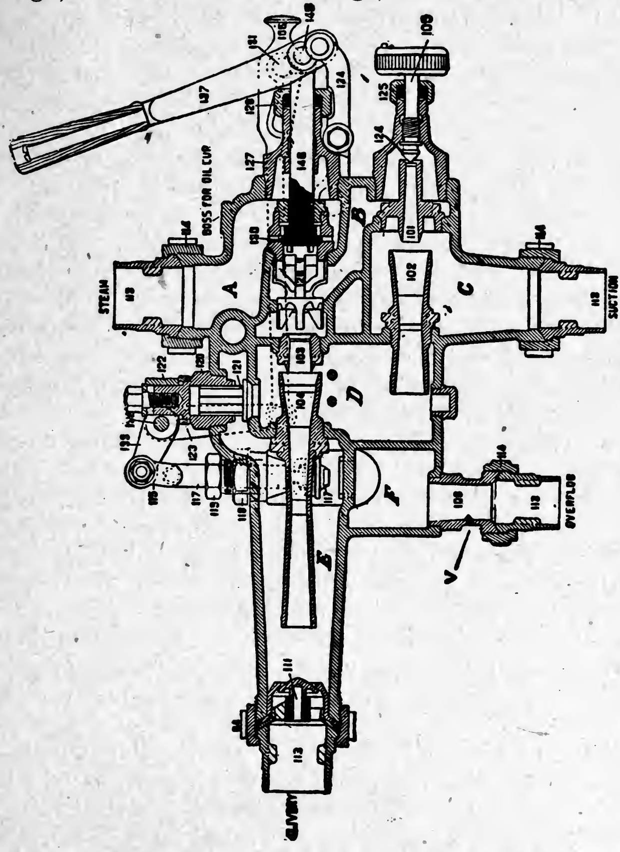
warm the feed water passing to the main steam nozzle as to break its action, or if the heater cock check 26 also leaked slightly (as it invariably does), air would be sucked in and cause the injector to break the same as if there was an inlet of air in the feed pipe. In case the injector breaks when steam pressure has fallen somewhat, and no apparent cause, it is undoubtedly due to valve 19 leaking, and the remedy is to close check 35. It is normally carried with the letter O on the square spindle end upward. To close it, turn the letter O down and letter S upward. If valve 19 leaks it will also prevent prompt lifting of water when the injector is to be started. If the injector breaks on account of temporary shutting off of feed water, the steam cannot blow back into the tank valve 19; seating prevents this. The steam passes out at the overflow until the action of the steam jet at the steam nozzle has again sucked up the water, whereupon the Simplex goes to work again, without any manipulation whatever on the part of the engineman.

Now we will take up a double tube injector. The Hancock inspirator has an extremely wide range of action.

Referring to cut of the Hancock inspirator, chamber A contains the steam from the boiler. To start, draw the lever 137 until the lifter steam valve 130 is open. In this position it is against the forcer steam valve 126, the steam pressure tends to hold these valves seated and you can feel the resistance when the lifter (shown black in the cut) is open against the forcer valve. Now the steam will pass through valve 130 in chamber B If the regulating valve at end of spindle 105 is open, steam will rush through lifter steam nozzle 101, and as it passes into lifter tube 102 will create the suction, as in other injectors, that raises the water to it.

At this point the lower tubes and valve, in conjunction with the upper valve 130, have the functions simply of a water lifting device. The pressure of water in chamber D will raise intermediate overflow

valve 121, pass through it into chamber E, through final overflow valve 117 into chamber F, and its discharge at fitting 113. Upon the appearance of water at the overflow the handle is pulled out as far as it will go, which does two things, closes the final over-



The Hancock Inspirator

flow valve 117 by means of connecting rod 106, crank 133 and link and stem 115 and 117. The forcer steam valve 126 is pulled wide open and full boiler pressure of steam passes through it, narrowing to a powerful jet through tube 103, from which it rushes into forcer

combining tube 104, picking up the water in chamber D and so highly energizing it as to force open the line and boiler check valves and enter the boiler. Of course chamber E is filled with a volume of water at greater than boiler pressure before it can be delivered to the boiler. The final overflow valve 117 must have a tight seat or it will waste water. The pressure in chamber E closes intermediate overflow valve 121 and it must not leak or the spill of hot water will destroy the combination in the forcer tubes. Now the opening of forcer steam valve 126 changes the lower tubes 101 and 102 from a common water lifter into a complete injector itself. Through chamber B, valve 124 receives as high steam pressure as does the upper or forcer valve. The water passing through tube 102 is highly energized, therefore the water is delivered to the main or forcing injector at chamber D instead of being dead as is the feed water of single tube injectors, has a force of its own and the duty of the steam through valve 106 and tubes 103 and 104 is to increase the force sufficiently to overcome the resistance of boiler pressure. It may now be apparent why a Hancock inspirator put to work at, say, 190 pounds steam pressure, will continue to work often until there is hardly steam enough to move the engine. The only water used by the forcer or upper tubes is just what is furnished to them by the lower or lifter tubes. As the steam pressure decreases, the power of the forcer for energizing water decreases, but the steam that goes to the lifter is decreased also and its capacity for delivering water to the forcer is reduced in exact ratio to the power of the forcer to use it. Inversely, as the steam pressure increases, the injector cannot break for want of water supply, because the increase of steam pressure supplies the lifter tubes with power to throw more water to it, a splendid boiler feeder if used right, but it can be deranged by bad treatment. The overflow valves 117 and 121 must not be allowed to get limed up and leak. If valve 117, the final overflow, is ground and worn away until its stem must descend lower in closing, and

the stuffing box around stem 117 is packed too full, link 115 will strike the packing nut 119 and prevent the valve from shutting off tightly while the inspirator is working, permitting water to waste at the overflow. In the overflow nozzle 108 there is a small vent port drilled at the point indicated V. When the inspirator is closed off after working, the final overflow valve is opened and the water in chamber E escapes. Now if this vent port V be stopped up, the water from chamber E induces a siphon and if it be the left hand injector (only used occasionally), nearly all the water in the tank can siphon out at the overflow. If this vent port is open, air entering breaks the circuit. Quite often fitting 108 is removed and the overflow pipe screwed directly into the body of the inspirator, and no air hole drilled in it. Then the only way to avoid losing water is to break the inspirator before shutting it off. That is done by closing off the lifter valve by the wheel handle, which stops the delivery of water before the operating handle is pushed in. All these instruments can be converted into heaters by closing the overflow valves and opening the starting levers slightly. With the inspirator the connecting rod 106 is lifted and disengaged from stud 131 of the handle and drawn clear back until the overflow valve is closed. Then the handle is drawn out just enough to furnish steam enough for heater purposes.

WHY INJECTORS FORCE ONLY PART OF THE WATER INTO THE BOILER.

Where the injector lifts the water, but forces only a part of it into the boiler, the other part going through the overflow to the ground, is often caused by an insufficient water supply, on account of the feed pipe having too small an area in proportion to the size of the injector, a partly closed tank valve, or kinked hose, or the water valve in the injector may not have its full opening, insufficient lift of the boiler check or the line check only opening part way, due to corrosion, obstructions in the nozzle caused by cinders, scales,

waste, etc., passing through the strainers. Incrustation or corrosion of the nozzles by limy deposits will also cause the injector to spray and work improperly.

TO REMOVE FOREIGN MATTER FROM TUBES.

In case of an accumulation of foreign matter in the steam, combining or delivery tubes, that interferes with the working of the injector, it can be removed as follows: First shut off the steam at fountain, then take out main steam valve at body of the injector, then use a piece of wire to remove the obstructions.

TANK VALVE DISCONNECTED.

In case of the tank valve becoming disconnected or closed, it can generally be displaced or opened by closing the heater valve and opening full the steam throttle of the injector, which will allow the steam to rush through the feed pipe and hose, striking the under side of the tank valve with such force as to unseat it.

TO OPERATE INJECTOR WITH DISCONNECTED PRIMER.

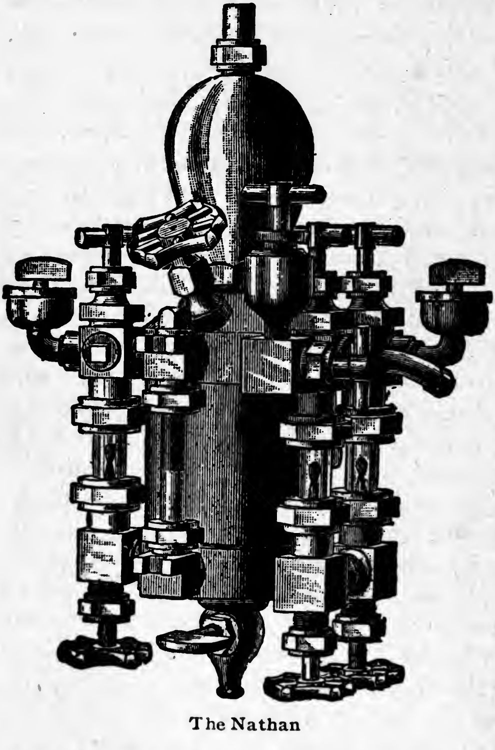
Where the injector has an independent priming valve, should it become disconnected, the injector can be operated as follows: Shut off the main steam valve at the fountain, take out the priming valve, and, of course, connect it up if you can. If this can't be done, keep the prime valve out and put back in their places all other parts. Then open the main valve at the fountain, just enough to cause the injector to prime. After priming the main valve must be opened enough to supply the necessary amount of steam to work the injector. Then open the injector throttle and it will go to work. When shutting off the injector in a case of this kind, the main valve at the fountain should be shut off first and then the throttle closed. If you should shut off the injector throttle first the injector would still remain primed and possibly waste your water.

TO RESEAT A BOILER CHECK.

If equipped with a frost cock, open it, which will allow the pressure from the boiler that passes the check valve into the delivery pipe to escape instead of going back through the injector. Tap the check valve cage lightly on the under side, as it will assist in reseating the valve, being careful not to strike hard enough to dent or spring the cage in which the check valve operates. Should the injector prime after you have opened the frost cock, try to put it to work, and the water entering the boiler will generally remove the cause of the check sticking or not seating. In case the check will not seat or you can't start the injector by the above method, you should close the heater and water valves to prevent the hot water blowing back into the tank, where it might cause the feed water to become overheated. If the water valve will not close, you can disconnect the hose from the feed pipe and open the heater cock, which will allow the hot water to blow onto the ground instead of back into the tank. If your other injector will not supply your boiler, it will be best to get onto the first siding and fill the boiler, thus reducing steam pressure. Then the delivery pipe can be disconnected at the check valve, when, with the use of a suitable rod or wire inserted into the check valve case under the check valve, you can reseat it. Should the check have a frost cock tapped into the lower part of its casing, you can remove it and insert a rod or wire and raise the check farther off its seat, allowing any foreign matter to be blown off the seat, which would allow the check to reseat. Should the check be equipped with a stop valve you could shut it off, stopping the steam and hot water from blowing back into the injector. In this case prime the injector when cool and put it to work, then open the stop valve on check again.

A CHAPTER ON LUBRICATORS.

The locomotive lubricator has almost entirely replaced the old style oil plugs or cups. Their universal adoption was due to the fact that they would feed oil to the cylinder under steam pressure and could be regulated and fed continuously, besides using the oil economically.

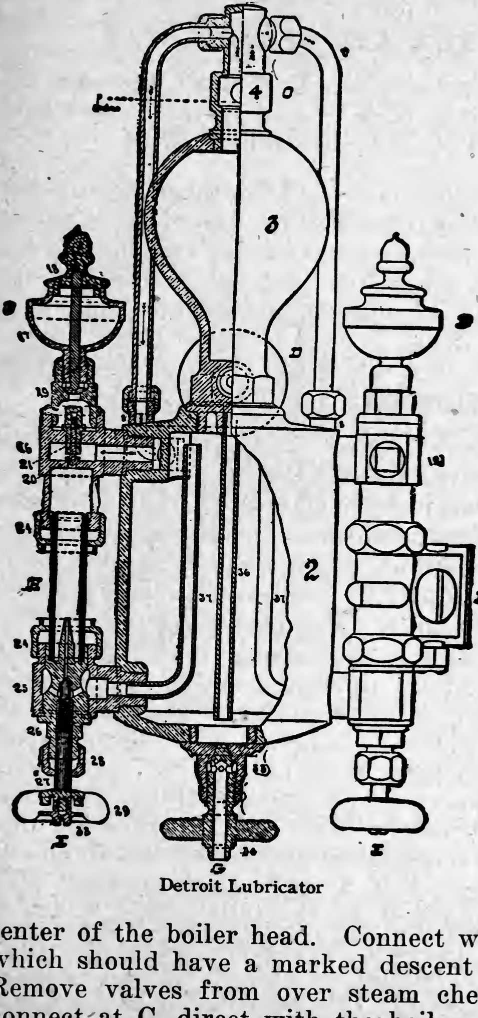


The Nathan

With the old style oil plugs, formerly in use, it was necessary to shut off steam pressure before the cylinder could be oiled. The lubricator overcame this difficulty and at the same time supplied a means of continuous feed, which is capable of very accurate adjustment. Lubricators are made in various forms, some supplying oil to the steam chest and cylinders only, others to the air pump only, but the later designs combine both cylinders and air pump feeds. The two lubricators in most general use are the Nathan and Detroit. The first illustration is an exterior view of the old style three feed Nathan. The next cut shows a sectional view of the old style triple feed Detroit lubricator.

THE MODE OF ACTION.

In this lubricator, as in all others, the oil rises to the top of the water, which is condensed steam, and then passes down through the pipes, as shown in the illustration, then out to the feed valves, where the supply is regulated. It then passes up through the sight feed glasses, which are filled with condensed steam; thence into the oil pipes to the cylinders and air pump.



Detroit Lubricator

How to Attach The Lubricator.

The lubricator should be supported with a heavy bracket (two by seven-eighths); preferably in the center of the boiler head. Connect with tallow pipes, which should have a marked descent to steam chests. Remove valves from over steam chests. For steam, connect at C, direct with the boiler, always allowing pipe to descend gradually to the boiler to permit the

surplus condensation to flow back to boiler. (With reference to cut of sectional view of Detroit lubricator.)

TO FILL AND OPERATE.

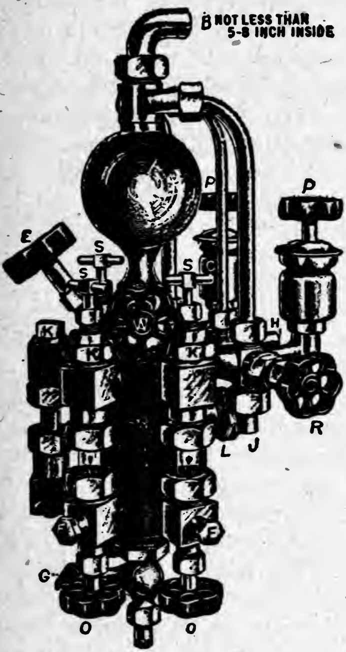
To Fill.—Close valves D, E, E and I, take out filling plug, open drain cock G, and when drained shut drain cock, and fill with clean strained oil.

To Operate.—Open steam valve to boiler for boiler pressure, then valve D, regulate to feed with valves E, E and I. B B—auxiliary oilers—are entirely independent of the lubricator, and are to be used the same as old cab oilers, when necessary, by simply closing the engine throttle.

THE MICHIGAN LUBRICATOR.

This lubricator, which is quite popular, has some points of superiority over lubricators of similar nature now on the market, in view of the fact that it, in connection with automatic steam chest plugs, is designed to overcome one of the great difficulties in locomotive valve lubrication, to-wit: Condensation and hold up of oil in the pipes when the engine's throttle is open. The principle of this device, except for the auxiliary oilers, is not materially different from that of all other sight feed lubricators. The auxiliary oilers are so arranged and constructed as to permit of oiling the valves and cylinders without shutting off the locomotive throttle, which is a very meritorious feature. No choke plugs are used with the Michigan, the function performed by them being taken care of by the automatic steam chest plugs. A is a sectional steam chest plug complete with a section of the tallow pipe attached, and shows the ball valve in the position it occupies on its seat, when the engine throttle is open. It will be seen from this that the full area of the large center opening, as shown in B, is available for the passage of oil from the lubricator to the steam chest. When the

engine throttle is closed, the ball valve, by the pressure from the lubricator, is rolled up on to the large opening, leaving only the small opening (marked choke in B), through which oil and steam can pass to the steam chest. In handling a locomotive equipped



L—Lock nut to secure lubricator to angle iron

B - Union to connect pipe for admission of steam

J-J—Unions to connect cylinder feeds to tallow pipes.

H—Union to connect air pump feed

N—Steam valve for boiler pressure (not shown)

E Filler plug

W—Valve to admit water from condenser to oil reservoir

O-O-O—Regulating feed valves

C-C—Auxiliary oilers operative with throttle OPEN or closed

P-P—Auxiliary oiler filler valves

R-R—Auxiliary oiler feed valves

S-S-S—Lifting stems to hold automatic check valves off their seats so glasses will fill with water of condensation when empty

F-F-F—Valves to drain sight feed glassss without emptying oil reservoir

K-K-K—Removable plugs for renewing or cleaning sight-feed glasses

I—Gage glass

G—Valve to drain oil reservoir

The Michigan Lubricator with Names of Parts

with one of these devices, it should be borne in mind that if the valves get a little dry, **pulling the engine throttle wide open** is the **remedy**, as that will have the effect of raising the pressure in the steam chest high enough to balance that in the oil pipe, thus allowing the ball valve to drop and bringing into use the large port through the plug to the steam chest.

TO OPERATE.

Steam for lubricator should be taken from turret if large enough, or from dome through an independent dry pipe of one inch iron pipe size, or its equivalent. When the lubricator is first applied, blow out thoroughly, then close all valves.

Automatic Steam Chest Plug

To Fill.—Remove filler plug O and fill the reservoir with clean strained oil. If there is not sufficient oil to do so, always use water to make up the required quantity. This will enable the feeds to start promptly.

Steam Valve. — The regular boiler valve should be left wide open, and the steam valve B at top of condenser must also be kept wide open while the engine is in service.

To Start Lubricator.—First, be sure that the regular boiler valve is open. Then open steam valve B at top of condenser wide open and keep wide open while lubricator is in operation. Allow sufficient time for condenser and sight feed glasses to fill with water. Second, open with water valve D. Third, regulate flow of oil to cylinders by valves E E and to air pump by valve L.

To Operate Auxiliary Oilers.—See that valve H is closed. Then open valve X and fill body of oiler. Close X after filling and open H.

To Re-fill.—Close valves E E and L in advance of valve D. Open drain plug G, then filler plug O. Refill and proceed as before.

Blowing Out.—Blow out lubricator once a week or oftener if necessary.

BULL'S EYE LUBRICATORS.

It has long been realized that in the design of all lubricators in use up till the advent of the Bull's Eye lubricator, there were certain inherent defects which it was necessary to overcome before a satisfactory solution of the lubricator question could be reached.

With the coming of increased steam pressure now used on modern locomotives, there arose conditions which proved the lubricators then in use were practically unfit for the service which modern conditions has brought about. This was proven by the breaking of glasses, often injuring the enginemen, cutting off valves, failure to make time schedules, leaky joints, and other troubles, along with the increase of cost of maintenance, to such an extent as to affect the successful operation of the locomotive.

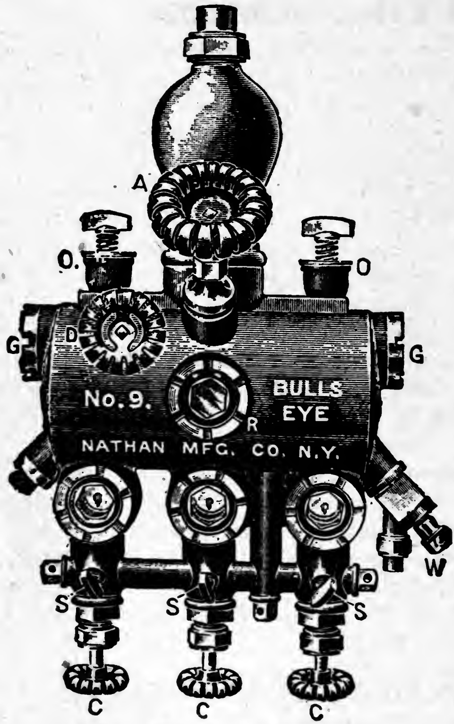
By careful study of the situation and of the lubricators then in use, makers came to the conclusion that a radical change in lubricator construction was imperative and that such changes must eliminate the danger and defects of the old style lubricators, the results of which have produced the Bull's Eye type of lubricators of the present time.

THE NATHAN BULL'S EYE LUBICATOR.

Construction and Operation.—We give two views of this popular lubricator. Fig. 1 shows a front view and Fig. 2 a sectional view. This lubricator is designed to withstand the increased steam pressures used on present day locomotives, and can be relied upon in all conditions of service. This type of lubricator is provided with a new form of disk glass, that it is claimed will not break under any condition of service, thus eliminating the danger to enginemen and delays

to trains caused from the breaking of the tubular glasses used in the old style of lubricators. Its construction has also been simplified in other ways.

There are no brackets to work loose, thereby causing leakage and breakage of glasses. All glasses are set in casings that screw into the body of the lubricator, thus making their removal for repairs and inspection far more convenient than with other types. There is also a reserve glass carried set in a casing provided for that purpose in front of the lubricator, all ready for use if needed. The cylinder oil outlets are provided with reducing plugs of a specified bore, the importance of which is in the relative proportion of their interior diameter to the reduced openings at the steam chest. The oil pipe at its steam chest connection must be provided with a choke of not less than three thirty-seconds, or more than one-eighth of an inch in diameter. This choke at the steam chest is necessary to the proper operation of the lubricator.



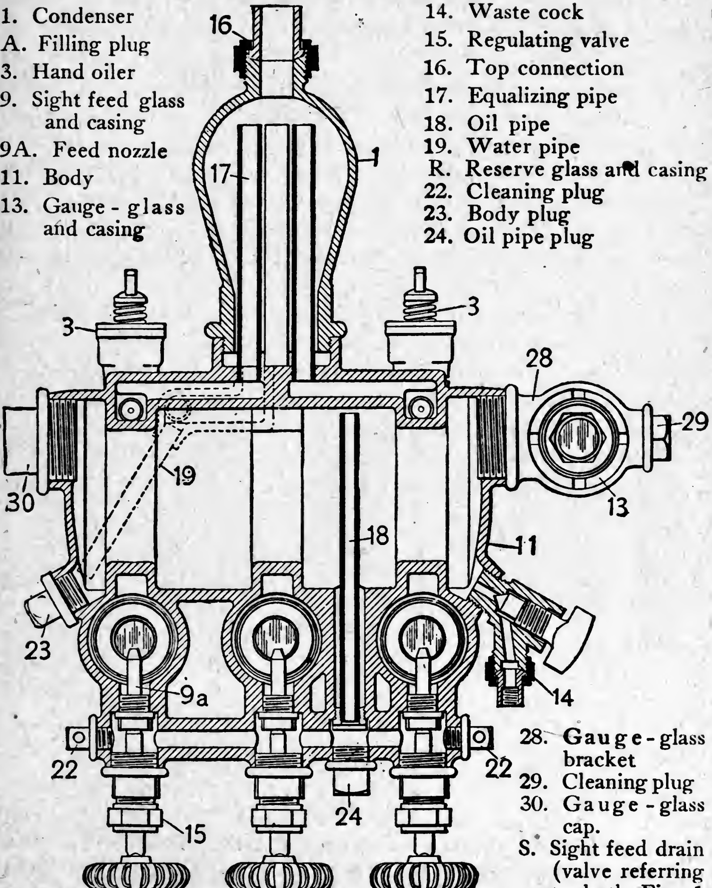
FRONT VIEW.
Fig. 1

CARE AND CLEANING OF LUBRICATORS.

Too much care cannot be taken to prevent stoppage by corrosion, particles of foreign substance, the

NAMES OF PARTS

1. Condenser
A. Filling plug
3. Hand oiler
9. Sight feed glass and casing
9A. Feed nozzle
11. Body
13. Gauge - glass and casing
14. Waste cock
15. Regulating valve
16. Top connection
17. Equalizing pipe
18. Oil pipe
19. Water pipe
R. Reserve glass and casing
22. Cleaning plug
23. Body plug
24. Oil pipe plug



28. Gauge-glass bracket
29. Cleaning plug
30. Gauge - glass cap.
S. Sight feed drain (valve referring to both Fig. 1 and Fig. 2)

Fig. 2

sediment introduced through unstrained oils. A lively blowing out with steam every week or two and a thor-

ough cleaning with hot lye about every three months is very beneficial. Care should be taken to keep all packing nuts well set up to prevent bleeding. When finishing a run, close feed valves first and steam valve at boiler last. Leave all other valves open. Steam valve should always be opened first and closed last.

TO CLEAN LUBRICATOR.

When cleaning the lubricator shut water valve off; open waste cock 14, to drain lubricator of its contents, then open all feeds, take out cleaning plug 22, open water valve and steam valve wide. Steam will then pass down through equalizing tubes 17, thus forcing the contents out of the sight feed glass 9, through the feed nozzle 9a, and regulating valve 15, into the oil channel and out at the opening of cleaning plug 22. To blow out oil pipe 18, all regulating valves 15, and waste cock 14, should be closed, and oil pipe plug 24 removed, which allows the steam to pass through the oil pipe to the atmosphere. To clean out water pipe 19, body plug 23 must be removed and water valve opened. To clean the gauge glass, take out cleaning

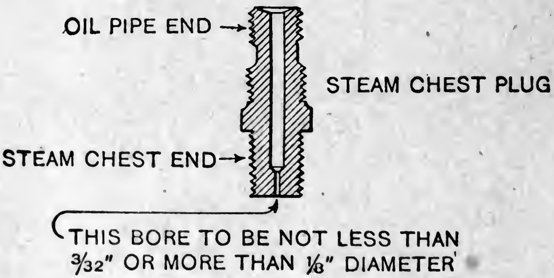


Fig. 3

plug 29, then open steam and water valves. To clean the sediment off of sight feed glass, shut regulating valve 15, open sight feed drain S, and this will allow the steam from the equalizing tube to remove all foreign matter from the glass. This also cleans the reducing plug.

The filling and starting of this lubricator is done the same as the old style Nathan lubricator.

PUTTING IN GLASSES.

First remove the follower, then the washer, and then the glass and gasket, and when replacing the glass put the gasket in place first, next the glass, then the washer and follower.

Fig. 4 shows a reserve glass set in its casing all ready for use when needed. Should a glass break, the old casing should be taken out and replaced by the reserve glass and casing, after which tighten up the follower slightly, and the glass is ready for service.

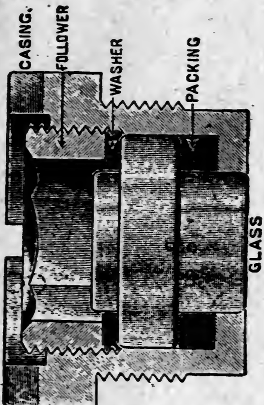


Fig. 4

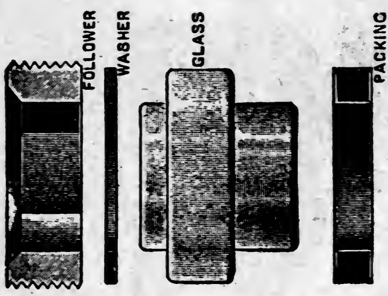


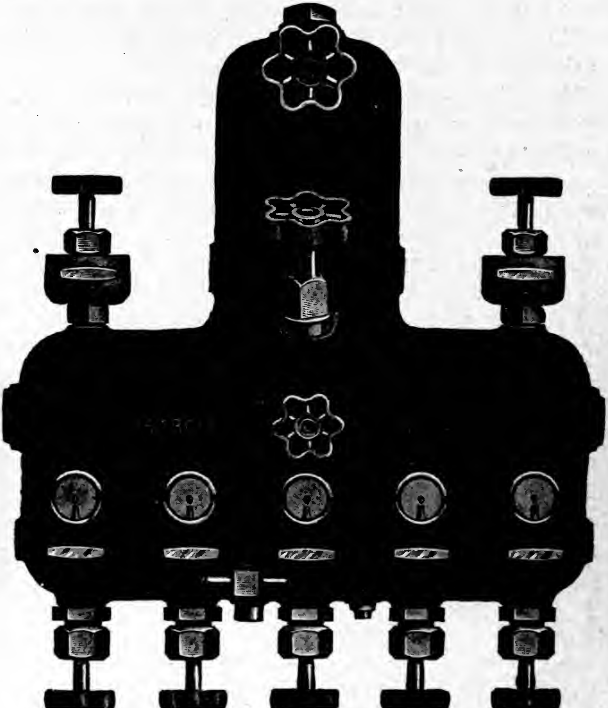
Fig. 5

Fig. 5 illustrates packing, glass, washer and follower, as they should be when put in their respective places in the casing, as shown in Fig. 4.

THE DETROIT NO. 41 AND 21 BULL'S EYE LUBRICATORS.

The Detroit Lubricator Company has placed a triple sight feed lubricator, also a five feed one of the same pattern, which is of the Bull's Eye design. These

lubricators are known to the trade as the Detroit Number 21, three feed, and Number 41, five feed, lubricators. For the sight feed feature they employ glass discs about one inch thick. Thus all danger of broken glasses is removed.



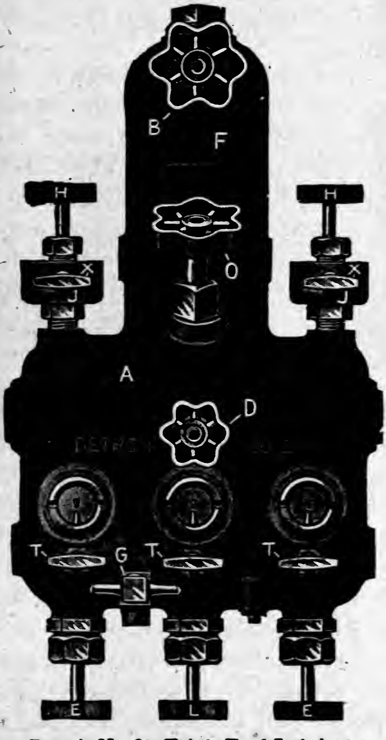
Detroit No. 41, Five Feed Lubricator

This lubricator has very few joints and only about half as many parts as their old style cups. They operate, however, on exactly the same principle as the old style lubricator. It will be noticed that the oil is fed to the sight feed chamber from a point entirely within the body of the lubricator, so there is no danger of the oil becoming chilled in cold weather. We give cuts

of both the Five Feed No. 41 and the Triple Feed No. 21, external views, also a sectional view of the No. 21, as it is in more general use than the No. 41, which is principally used on compound engines. We also illustrate their method of packing the glasses and of their automatic steam chest plugs and valves.

EXPANSION CHAMBER.

This is a feature that has been added to this type of lubricator, in order to provide a space for the expansion of oil, thereby relieving the body to some extent from that abnormal pressure when the cup is filled with cold oil, and at the same time preventing the oil from expanding back up into the condenser, as it did in the old type of lubricators. The chamber varies in capacity according to the number of feeds. As has been noted, the hotter the oil before it is put into the lubricator, the less it will expand.

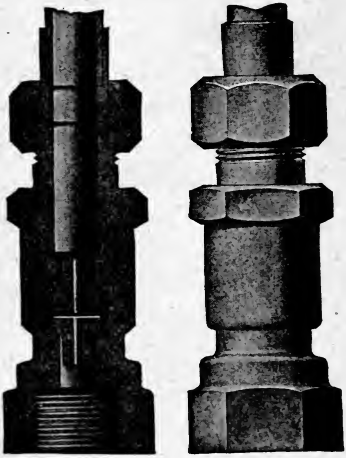


Detroit No. 21, Triple Feed Lubricator

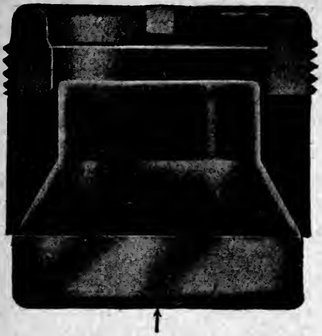
AUTOMATIC STEAM-CHEST PLUGS AND VALVES

The function of these automatic steam-chest plugs and valves are two-fold. First, that by their use and

location, the lubricators feed against a constant boiler pressure and not against a fluctuating pressure, as was the practice in the earlier type of lubricators. Second, the valves or chokes restrict the flow of steam to the steam chest to that volume that will balance the feeds to a uniform rate.



Regardless of the position of lever or throttle, the valves are so designed and constructed that they are reversible and have about three-sixteenths of an inch lift, this movement between the two seats enabling the valve to be self-draining. A very important feature as it prevents scale or any foreign substance from accumulating or restricting the flow of oil and steam to the steam chest and cylinders. The openings in these valves are five sixty-fourths of an inch. The constant flow of steam through the lower openings of these valves will in time enlarge these openings to such an extent that the lubricator will feed faster while the engine is drifting or at rest. In fact that condition is the cause of the engineers to complain that the locomotive feeds race. All that is necessary to rectify this condition is to reverse the ends of the valves, when both ends have become worn out, the valves must be replaced by standard ones of the proper opening. A reasonable degree of attention regarding these valves in the automatic steam-chest plugs will result in a very satisfactory working lubricator and a decided increase in valve oil mileage, two factors that are highly desirable.



GLASS AND METHOD OF PACKING.

Do not screw up too tightly the feed glass follower (see cut), as this will only serve to injure the packing. There is no danger of leakage at this point as the glass and packing are so designed that the greater the pressure from the inside the better the joint.

The direction of the pressure is indicated by the arrow as shown in cut.

POINTERS ON DEFECTS AND OPERATING THE DETROIT BULL'S EYE LUBRICATORS.

Filling.—If there is not sufficient oil to fill the cup always use water to make up the required amount. This will enable the feeds to start promptly. If at any time it becomes necesary to fill the lubricator with cold oil and the engine will remain out of service for some hours ,do not fail to turn on slight steam pressure from the boiler and open valve D in order to prevent any excessive pressure from expansion of oil.

Note A.—The steam valve B must be opened wide when the locomotive is in service to allow condensation to enter the condenser otherwise condensation will be diverted to equalizing tubes. The feeds will generally slow down as the water of condensation decreases.

Note B.—When getting a new or rebuilt engine ready for service or when using soda ash boiler compounds or when running in bad water districts, impurities will be carried over into the condenser and will gradually accumulate at base of water valve until the water is completely shut off. Sometimes these impurities lodge above the water check. While this is taking place the feeds are affected the same as described **in**

Note A, and when this passage is finally closed by the sediment the feeds will cease altogether.

How to Rectify.—While engine is in service close all feeds and water valve, open drain cock 2105 and allow about one-half pint of water to drain off. Close drain cock and open water valve quickly. The condenser pressure will then force this sediment into bottom of lubricator, where it can be blown out in the usual manner when the lubricator is empty.

Note C.—If the lubricator is reported syphoning look for the trouble at water check 2238. Cause, scale or borings prevent ball check from seating or the check may have been lost by removing plug 2239.

Small Drops of Oil.—The cause of a small drop of oil or the variation of size of drop during a trip in alkali, salt water or oil well regions through which railroads pass. The water supply becomes impregnated with saline matter. This is carried over into the lubricator mechanically by the steam, so that the water in sight-feed glasses contains considerable of it and the amount increases as the engine proceeds on the trip until it crystallizes around the feed cones, thus gradually diminishing the size of the opening for the drop. Should the engineer undertake to force the feed it will result in the oil flowing in a very slender stream, scarcely perceptible. If this condition is not corrected the salt crystal will completely close the feed cone orifices. Salt water is more buoyant than fresh water, and for that reason it forces the drop of oil off of the feed cone in less time the result is a small drop of oil and more drops per minute.

How to Rectify.—Close all feed stems, open all sight-feed drain stems and blow out thoroughly. The action of the steam on feed cones will dissolve the salt crystals. Allow reasonable time for condensation. Start the feeds and the drop will be renewed.

Air Bound.—This condition is almost invariably brought about whenever it becomes necessary to fill

the lubricator on the road. The temperature of a lubricator at such times is very nearly that of the steam pressure temperature. Sometimes the water feed valve or feed stem seat may leak and in order to fill the lubricator in this heated condition it is necessary to shut off all steam pressure to the lubricators, including the air pump and owing to the high temperature of the condenser the water flashes into steam, practically emptying the condenser and feed glasses of all water. The oil reservior being very hot, the oil expands rapidly and the filler plug is usually put in before the reservoir is full. The steam and water pressure are hurriedly turned on and the feeds are opened before sufficient time has elapsed for condensation to accumulate. The feeds will not respond under such conditions because the positive and negative pressures have equalized and the lubricator is said to be air bound.

How to Overcome.—Open all feeds and any one of the sight-feed drain stems. This will allow the water in the oil tubes and the air or gas occupying the higher space in the oil reservoir to escape to the atmosphere. The oil will quickly follow, then shut this feed and vent stem until the condensation again fills the sight-feed chamber and your lubricator will go to work.

Getting New or Rebuilt Engines Ready for Service.—Disconnect oil pipe at steam chest and blow out thoroughly both oil pipes and automatic steam chest valves, also disconnect couplings to air pump and see that choke is free. Do this several times while getting the engine ready for service.

Irregular Feed or Racing.—If a lubricator feeds irregular look for the trouble at the automatic steam chest valve or in such chokes as are located at the lubricator end of tallow pipes. When the opening through any of these chokes is enlarged above the standard the feed will race, or be more rapid.

Care of Lubricator. — With high steam pressure there is a tendency, even with good valve oil, to deposit a gummy substance resembling vaseline around the feed

stems and cones. This substance can be removed and the glasses cleaned and filled by the following method: Leave the pressure turned on and close all feeds but one. Open vent stem to this one, which will cause the condensation to circulate and thoroughly cleanse the feed stem, cone and glass. Close vent stem. The glass immediately fills with condensation from lubricator. Close feed stem, repeat same operation with other feeds. Close the water valve. Blow out body and fill with oil in the usual manner.

Feeding Around the Metal Between the Glasses.—If reported so, there are but two causes for this.

First.—The feed cone No. 2273 is loose or has a faulty seat. The oil will flow upward around the clearance of the thread, passes feed cone seat, adheres to the metal, and passes around and out of sight feed chamber by capillary action.

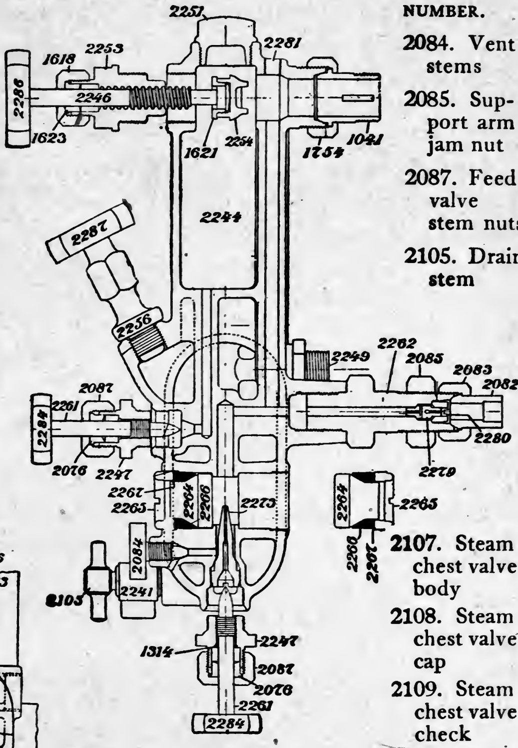
Second.—Sediment is allowed to gather around feed cone to the extent that the oil adheres to it, creeps down and passes out of sight feed chamber, for the same reason as in the case of a loose feed cone, viz: Capillary action.

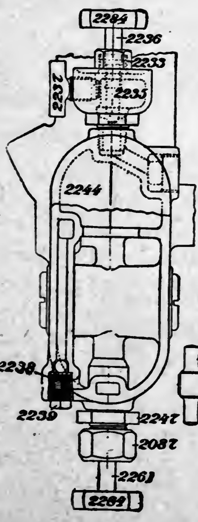
Treatment.—In the first cause, tighten feed cone No. 2273. The second cause is visible, open vent chamber. This will remove the sediment. Should the engineer not be an observing man, he will report the lubricator as feeding out several times on the road or that feeds stop, or feed irregularly.

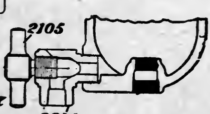
Round House Repairs.—If a lubricator is reported as not feeding, look for the trouble as described in Note A, or in oil tube No. 2270. Should this oil tube become loose in bushing No. 2277, or bushing loose in body, water would find its way into oil feed chamber—it is understood that water occupies the space in both the oil tube and chamber, when the lubricator has fed empty or after condensation has been drawn from the lubricator body in the usual manner.

NAMES OF PARTS OF NO. 21 LUBRICATOR.

Numbered as shown in the four sectional cuts given.







NUMBER.

1041. One-inch tail pipe
1314. Feed stem ring
1618. Steam valve packing nut
1621. Steam valve disc lock nut
1623. Steam valve gland
1754. One-inch tail nut
2076. Feed valve gland
2082. Tail pipe
2083. Tail nut

NUMBER.

2084. Vent stems
2085. Support arm jam nut
2087. Feed valve stem nuts
2105. Drain stem
2107. Steam chest valve body
2108. Steam chest valve cap
2109. Steam chest valve check
2233. Hand oiler packing nut
2235. Hand oiler body
2236. Hand oiler stem
2237. Hand oiler filler plug
2238. Water check stop
2239. 11-16 plugs
2240. Gauge glass reflector
2241. Drain valve body

NUMBER.

2246. Steam valve stem

2247. Feed valve center piece

2249. Tallow pipe center piece

2251. Condenser plug

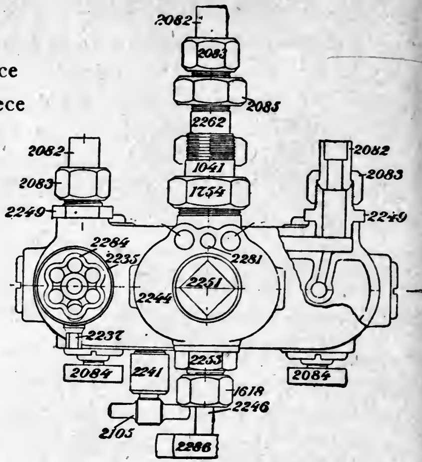
2253. Steam valve center piece

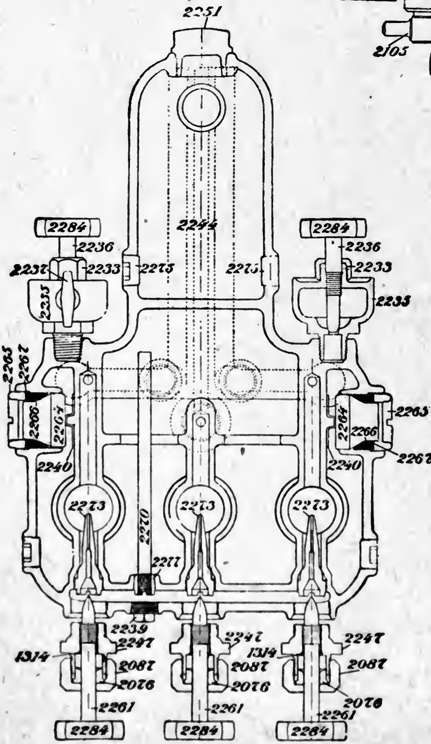
2254. Steam valve disc

2256. Filler plug

2261. Feed valve stem

2262. Support arm





NUMBER.

2264. Sight-feed glass

2265. Feed glass packing ring

2266. Rubber packing

2267. Feed glass washer

5-64—2270. Oil tube

2273. Feed nozzle

2277. Oil tube bushing

2279. Air break check

2280. Check seat

2284. Regulating valve handle

2285. Hand oiler handle

2286. Steam valve handle

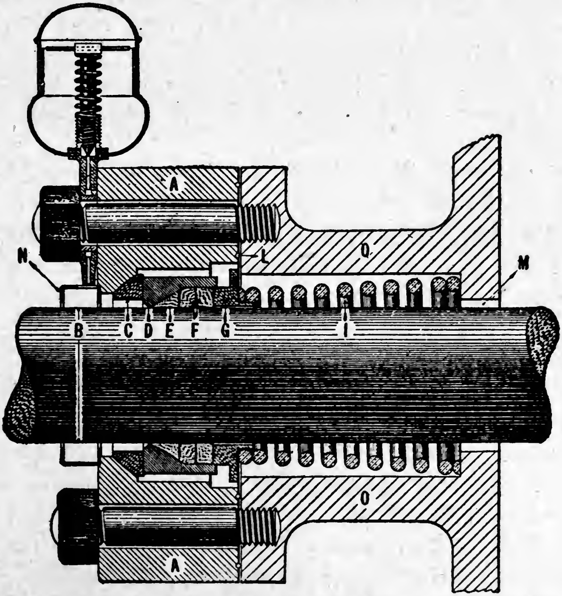
2287. Filler handle

METALLIC PACKING.

The use of metallic packing in locomotive service has become so thoroughly established that it is scarcely necessary to state that since the introduction of metallic packing the use of hemp and asbestos has been almost entirely discontinued. Various forms of packing are in use, but as the United States and the Jerome Metallic Packing are the two in most general use, we will illustrate and explain these two kinds only.

UNITED STATES PISTON ROD PACKING.

By reference to the cut, it will be observed that this packing consists of three babbitt rings (E and F), placed in a vibrating cup (D), whose interior form is conical. This cup rests against the flat face of the ball



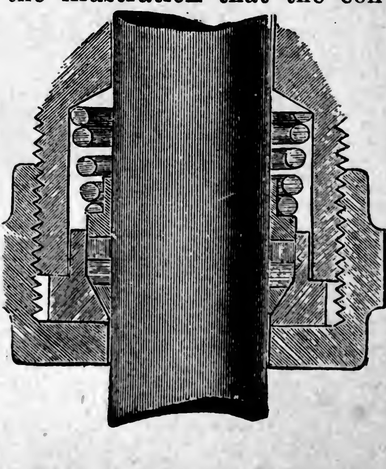
and socket ring (C), which in turn has its bearing against the gland or outer casing (A), the whole being held in place by the coil spring (I) and the flanged follower (G), which prevents any possibility of the parts

drawing back with the rod. It will be seen from this construction that the surface of the rod must be in good condition as well as round and parallel. It will be noticed that care has been taken to so construct the packing that the soft babbitt rings (E and F) are the only parts which can touch the rod, the idea being that when the rod runs in contact with any hard metal, its surface naturally becomes abraded and acts as a file upon the packing. It will also be seen that by its construction the packing may have a direct sliding movement upon the face between the vibrating cup and the ball joint, or may have a rocking motion between ball joint and case, or may combine both at once. By this device the packing never binds the rod, but follows it in all its vibratory movements. Thus the friction is reduced to a minumum. The lubricating device consists of an oil cup feeding into swab cup (N).

The following list of names of parts are shown in the illustration: A—Packing case or gland. B—Piston rod. C—Ball joint. D—Vibrating cup. E and F—Babbitt rings. G—Follower. I—Coil spring. L—Copper wire joint. M—Clearance room through cylinder head. N—Swab cup.

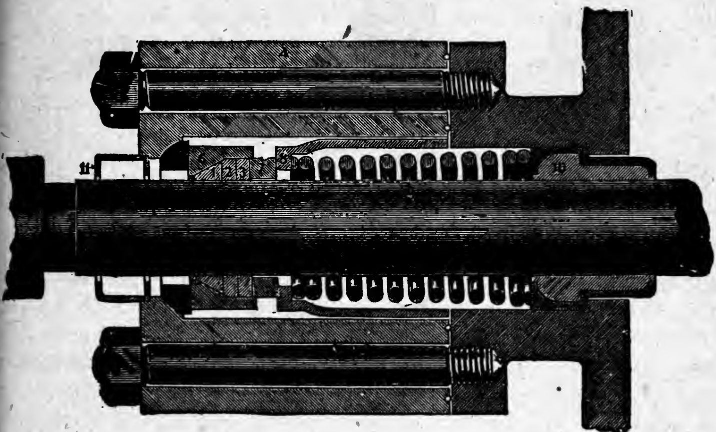
UNITED STATES AIR PUMP PACKING.

It will be seen by the illustration that the construction of the air pump packing is similar to that of the piston and valve stem. The form of the gland only being different, it will be seen that the cone is made small enough to vibrate in the stuffing box, and has a collar which prevents the gland being screwed up tight enough to compress the spring.



UNITED STATES VALVE STEM PACKING.

It will be noticed by reference to the cut, that a bush is placed in the stuffing box to carry the weight of the stem and yoke. It is quite natural that in time

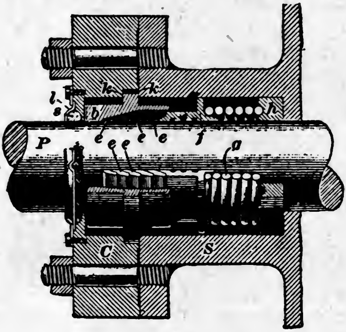


this support (11) should wear a flat place on the under side of the stem. This flat place would be the length of travel of the stem, and if the packing was placed close to the support, this flat place would travel into the packing and thus cause a leak. Therefore, the distance between the bush and the babbitt rings is equal to the travel of the stem, thus obviating the difficulty, the preventer (8) accomplishing the same results as the flanged follower of the piston rod.

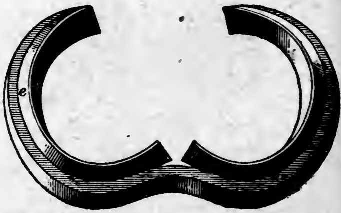
THE JEROME METALLIC PACKING.

A sectional view of the Jerome metallic packing is shown below in (a), while in (b) one of the packing rings is shown open, ready to be put around the piston rod without disconnecting the rod from the crosshead. In the cut, P is the piston rod, C the gland, S the stuffing box, b the cone or packing case, E E the packing rings, f the follower, h the back bushing ring that forms a seat for the spring g. K K are ground joints between the flange of cone b and the cap and stuffing box, l is

a swab case and s a swab for lubricating the piston rod. The packing rings E (cut b) are split so that a rod can be packed without uncoupling it. The Jerome valve stem packing is similar to the United States packing,



(b)



(a)

except that it is provided with a heavy brass set screw for clamping the valve stem if the engine is disconnected.

HOW TO TREAT HOT BEARINGS.

Valve oil or hard grease can be used on hot bearings that are too hot to be cooled by common engine or car oil.

Hot Eccentrics.—Should an eccentric run hot, it should be given plenty of oil, and examined to know if oil holes are open, also to see if cam bolts have worked loose. If so they should be tightened, as their being loose will cause the eccentric to bind in the strap. Should the cause be the strap being too tight, liners or shims should be inserted in the top and bottom of the strap. Never use water to cool a hot eccentric or strap.

Engine Trucks.—Should an engine truck be running hot, the brass and cellar should be examined and the cellar repacked if necessary. If equipped with water pipes for cooling purposes, the water should be turned on. If the brass is defective, a new one should be put in, and it should be known that the oil passages are open so the journal will get oil.

Trailer or Tender Trucks.—If running hot, they should be re-packed. If equipped with water line, use it. Examine brass, and if necessary replace with a new one.

Driving Boxes.—If running hot, be sure that oil holes are open, also that the cellar is properly packed. If the packing is not up against the journal, re-pack it. If equipped with water, turn it on and pull down wedge to keep it from sticking. If this does not help it, it should be relieved of some of its weight by running the wheel up on a wedge and putting a block between the saddle and frame, or between the equalizer and frame.

Rods.—If the back end of a connecting rod is running hot and throwing the babbitt, don't stop till all the babbitt is thrown out of the brass. Then stop and cool the pin off and slack up on the key. Clean oil cup and know that feed is working and fill with grease or good oil. Should the forward end of the connecting rod run hot you should know if the oil is feeding all right and that it is getting proper lubrication. If it is keyed too loosely it should be keyed up and if too tightly the key should be slacked up a little. The heating of the back end of the connecting rod can do no harm to the engine when given plenty of good oil and room on the pin. If the main wedge is down it should be set up as this is generally the cause of side rods running hot. Side rods should be treated same as connecting rods if hot.

Hot Guides.—Should the crosshead work too tightly in the guides, causing them to heat, there should be liners placed at both ends to shim them up if necessary. Cool them off with plenty of oil, and it should be known that the cups are full and feeding properly.

PRIMING.

Priming is generally caused by over pumping and can be detected by the muffled sound of the exhaust, which will not sound as clear and sharp as usual.

Priming is so similar to foaming that care should be taken until a test has been made, and then open cylinder cocks, ease off on throttle and shut off water supply. Priming is bad for the engine and a waste of fuel and oil, as it washes the oil from the valves and cylinders, and thus causes extra friction, also liable to cause damage to cylinder heads, as water won't be compressed to any great extent, and the piston being forced against it, is liable to knock out or damage the heads.

MALLET COMPOUND, GREAT NORTHERN RY., WEIGHT ON DRIVERS, 350,000 LBS. TRACTIVE POWER, 70,000 LBS.; LENGTH, 73 FEET, 2 INCHES.

OIL BURNING LOCOMOTIVES

As oil has become quite a factor in the fuel line in some parts of our country, perhaps a few words on the subject will not come amiss to the seeker after knowledge. The burner used on the engines described in the following articles is called or made by Messrs. Booth and Sheedy, and is used quite extensively through the oil burning part of Texas and other oil burning districts.

The Fire Box.—Of the engine is arranged for the use of oil as fuel by placing a wall of fire brick around the side and front to protect the sheets. Brick that are affected by extreme heat are used in preference to those that resist heat, as the former, after being superheated, will bind better when cooled and thereby resist the hard usage, caused by the vibrations and shocks of the movement of the engine. With the present system of using oil as fuel for locomotives, an atomizer is used, by which the oil is sprayed into the fire box.

The Atomizer.—Is the outlet for the oil supply, through which the oil is fed to the fire box. It is usually about twelve inches in length, and is in some cases divided into two compartments lengthwise, while in others it has three. The dividing partitions are parallel with the top and bottom of the atomizer. In the first style mentioned the oil passes through the upper compartment and steam through the lower, so as to heat the oil when passing to the outlet. In the other style the oil passes through the top compartment, steam through the center, and air through the lower, uniting at the end of the nozzle, so that the oil enters the fire box as a spray mixed with air. In both cases the fire box is filled with flame. The atomizer with two compartments is attached to the bottom of the mud

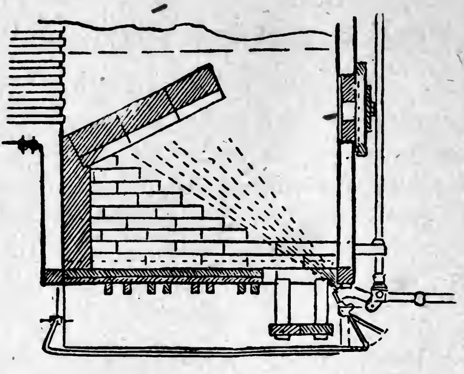


Fig. 12

ring, as shown in Fig. 12. In the other style the burner is located in the upper part of the brick portion of the fire box, as shown in Fig. 13. In deep fire boxes the atomizer is placed at the back end, as in this type of fire box the draft is strongest at that point. For the same reason, it is placed at the front end of the shallow fire boxes.

Adjustment of Burners.—The burners should be so adjusted that the oil will strike about the center of the front wall of the fire box. If the oil drops to the pan it will cause black smoke and a poor steaming engine. The black smoke would also indicate that more oil was being fed to the fire box than was being consumed. Sometimes the burner gets stopped up with sand from the oil or small pieces of waste drawn into the air inlet. The steam jet can be taken out of most burners and cleaned without disturbing the latter, and thus the trouble will be easily overcome. The blower should be used only strong enough to clear the stack of smoke, as too great a blast from it will create too strong a draft through the fire box, thereby reducing the temperature and cause a waste of fuel and leaking of flues and sheets.

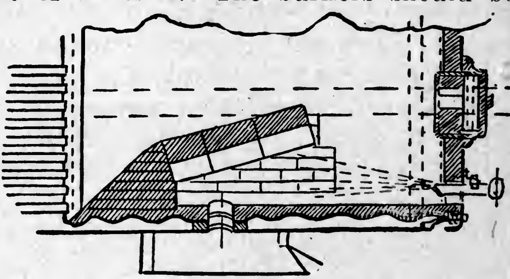


Fig. 13

Color of Fire.—The fire should have a bright ruddy color, and is so produced by feeding the proper amount of oil, and watching the regulating valve closely, and admitting the necessary amount of air. Where water has mixed with the oil it affects the flames and requires a greater amount of oil.

Drafting.—The draft arrangement is the same in oil burning engines as in coal burners. The draft in the stack can be regulated by adjusting the draft appliances so as to distribute it evenly throughout the flues.

Oil Line Obstructed.—Should the oil line become obstructed, close the firing valve, open the cock between the oil line and the heater line, turning the cock on the boiler head to the heater line on full, which will cause all obstructions in the oil line to be blown back into the tank. This can also be utilized to heat the oil in the tank, should the oil heater fail to work properly.

Starting the Fire.—In starting the fire in an oil burning locomotive at the engine house, a steam connection is made with the three way cock on the smoke box, acting as a blower and atomizer at the same time. A piece of oily waste, lighted, is thrown into the fire box ahead of the burner, then the flow of oil to the burner is started slightly, and the atomizer valve is opened just enough to spray the oil that is flowing from the burner, which will ignite immediately. The fire should be watched closely until steam begins to form in the boiler, after which the steam supply from the engine house can be shut off. Care should be taken to not have too heavy a flow of oil, as it would cause an explosion. The fire must not be allowed to go out, as this would let the oil run down into the pit, and possibly cause fire. To light the fire after steam has been raised, should it go out, first open the front damper and put on the blower strong enough to cause the necessary draft, open the atomizer valve long enough to blow out all the condensed steam that may be in the steam pipe of the burner, then close the valve, and put a piece of

lighted waste in front of the burner, and open the atomizer enough to carry the oil spray to the lighted waste, then open the regulator slowly, but it should be known for certain that the oil has ignited, which can be ascertained by looking through the opening in the fire box door. Should the oil not have ignited it will run into the pan, and when it does ignite will be apt to cause an explosion, which might destroy the arch and damage the pipe connections. Do not trust to the hot bricks to start the fire as the same results as above might happen.

When firing up an oil burner and steam is not to be had, wood may be used until a steam pressure of 15 or 20 pounds is obtained, but care must be taken to not damage the brick work in the fire box, and that the walls are in good condition, for should broken parts of the arch or wall drop on the floor of the fire box they might interfere with the working of the burner. The loss of steam pressure can be regained in much less time with an oil burning engine than with a coal burner, but the operation is very injurious to the fire box sheets, and the rivets on the inside of the fire box can in this way very easily be burned off by the intense heat of the fire caused by the increase of oil supply to the fire.

When Starting Engine.—The fireman must be at his post a reasonable time before the engine is started, so as to open the firing valve just enough to be sure that the action of the exhaust will not cause the fire to be put out, but not enough to cause a large amount of smoke. When the engine is cut back to its working notch the valves controlling the oil should be regulated accordingly. When first starting it is a good practice to open the blower about half a turn, as this will help consume the smoke between the exhausts and assist in keeping the boiler and tubes hot, as too much smoke causes a coating of soot in the flues, and as soot is a non-conductor of heat, it can easily be understood that the effect would be towards destroying the steaming qualities of the engine.

In Sanding the Flues.—The amount of smoke emitted from the stack can be taken as a guide as to the frequency with which the flues should be sanded. If there is much smoke after the engine is started, and the engine is to be worked hard, the flue should be sanded every ten or twelve miles. If the flues are kept clear of soot, every twenty-five or thirty miles is often enough, but the engine should be well sanded when going from the engine house to the train. About one quart of sand should be used at a sanding, and the funnel provided for sanding always kept in a position to carry the sand over instead of under the arch. Should the supply of sand run short you can take it from the main sand box or get it from the cinder pot in front end and use it over again.

Black Smoke.—Should at all times be avoided, and if in evidence shows faulty construction of brick work or improper methods of handling. The soot formed by smoke is a non-conductor of heat and will make an oil burning engine fail in steam quicker than any other cause. To pevent the smoke in starting or stopping, engineers should always notify the fireman when they are going to open or close the throttle.

Engines Drumming.—Is caused by faulty construction of brick work in the fire box, careless handling of oil valve by fireman, when engine is working slowly, or by atomizer being open too much.

Drifting.—While the engine is drifting down long grades the fire should be kept burning lightly and not allowed to get too low. It should not be shut off altogether, for the reason that it would reduce the temperature in the fire box, thus causing the flues to leak. While switching, the fire should be in about the same condition as when running along.

Putting out Fires.—First shut off oil valve on tank, allow oil to be burned from pipe to burner, then close firing valve, atomizer and dampers. It is important that dampers should be closed to prevent passage of cold air through fire box and tubes, when they are heated after the fire had been extinguished.

COMPOUND LOCOMOTIVES

THE VAUCLAIN FOUR CYLINDER COMPOUND.

The essential features of the Vauclain system of compounding are the use of four cylinders, one high and one low pressure cylinder for each side of the engine, and a single piston valve for each pair of cylinders.

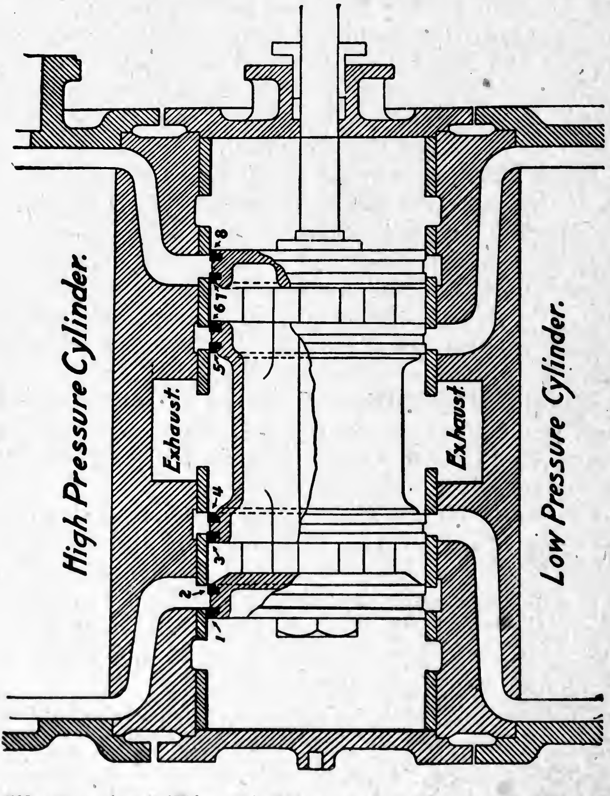


Fig. 1

Illustration (Fig. 1) shows the valve employed to distribute the steam to the cylinders. It is of the hollow piston type and works in a cylindrical steam chest

located in the saddle of the cylinder casting between the cylinder and the smoke box.

The steam chest is lined with a hard cast iron bushing, in which the various ports are accurately machined. The valve, as shown in Fig. 1, is double and controls the steam admission and exhaust in both cylinders. The exhaust steam from the high pressure cylinder becomes the supply steam for the low pressure cylinder. In starting heavy trains from a state of rest, the engine is called upon to exert its maximum power, and it is therefore necessary in compound engines to admit live steam to the low pressure cylinders as well as to the high pressure cylinders, which is accomplished by the use of a starting valve. This is merely a by-pass valve, which is opened to admit steam to pass from one end of the high pressure steam admission passage to the opposite end of the cylinder, and thence to the low pressure cylinder, thus exerting live steam pressure on both high and low pressure cylinders simultaneously.

TO OPERATE.

When starting the engine from a state of rest, the engineer should always put the reverse lever in full gear and open the cylinder cocks to relieve the cylinders of condensation. Also open the starting or by-pass valve to admit steam to the low pressure cylinders to enable the engine to start quickly and freely. After a few revolutions have been made and the cylinders are free from water caused by condensation or priming, the cylinder cock lever should be moved to central position, causing the engine to work compound entirely. This should be done before the reverse lever is disturbed from its full gear position. The reverse lever should never be hooked up, thereby shortening the travel of the valve, until after the cylinder cock lever has been placed in a central position.

The starting or by-pass valve should only be used in starting a heavy train from a state of rest, or when ascending a grade with a very heavy train. Where the speed is being reduced, or where more power is

required, drop the lever into full gear, open the by-pass valve and thereby retain the momentum of the train, as it is more economical to retain speed than to lose it and pick it up again. Do not, however, resort to this too often, and only when absolutely necessary, as the frequent use of the by-pass valve will result in waste of steam and increased repairs to the engine. When on a hard pull or grade, if the engine shows

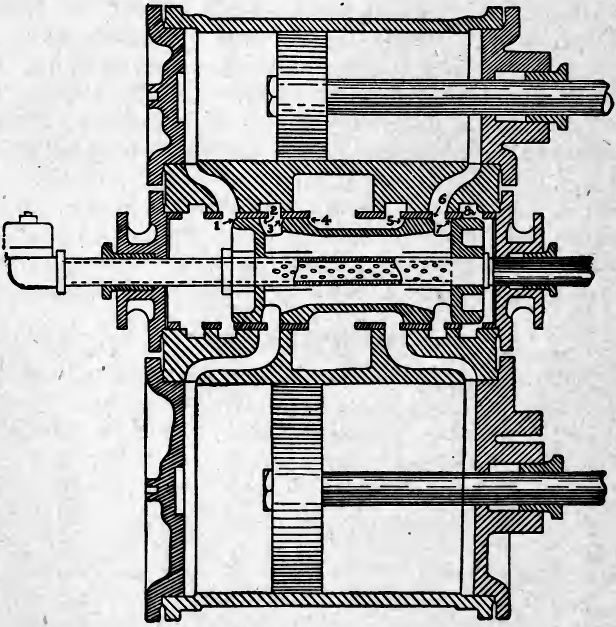


Fig. 2

signs of slowing up, do not hesitate to move the reverse lever forward, as it is perfectly practical to operate the compound engine, at any position of the lever between half stroke and full stroke without serious injury to the fire. When running on a descending grade, where the train would run without working steam, the lever should be in full gear, backward or forward, as the case may be, so as to give a full port opening to

the valves. On long descending grades use just enough steam to keep relief valves closed, thus giving a more free and smoother motion to the engine. Besides, this will aid in lubricating the cylinders. Do not reverse the engine except in case of emergency to prevent accident, when at high speed, as the piston valve cannot lift itself from its seat to allow the excessive pressure in the cylinders, caused by the reversing of the engine, to escape into the steam chest, as in the ordinary slide valve engine.

PISTON AND VALVE ROD PACKING.

Piston and valve rod packing should be given careful attention. Do not oil the packing too heavily. A little oil properly applied, and taking care that the oil cups and swabs are clean and in good condition, will insure a tight packing and increase mileage for the packing rings.

When glands need forcing up, use wooden bars, or for any other work where the bar is likelv to come in contact with stems or rods.

A small rough place made by an iron bar may cause the packing to blow badly, and necessitate a new set of packing rings.

LUBRICATION.

The cylinders should be properly lubricated. They should not require any more oil than those of a similar single expansion engine. This is due to the fact that sufficient particles of oil remain suspended in the steam after passing through the high pressure cylinder, which will properly lubricate the low pressure cylinder.

WATER.

Engineers and firemen should try to maintain a uniform height of water in the boiler, say about half of the water glass full. Too much water in the boiler causes wet steam to be carried over into the cylinders and increases the condensation in the low pressure cylinders, resulting in excessive strains on crosshead, pins and other parts of the engine's mechanism.

TESTING FOR BLOWS.

In Fig. 2 a section through high and low pressure cylinders and valve chamber is shown, the packing rings are numbered and referred to in the following manner: The rings governing admission and release of steam to high presure cylinder are 1, 2, 7 and 8, and those to the low pressure cylinder are 3, 4, 5 and 6. Rings 1, 2, 7 and 8 can be tested as follows: Place reverse lever in central position, thereby covering all ports, then open the throttle and admit steam to the ends of the valve. If rings 1 and 8 leak, the steam will blow through, filling both ends of the high pressure cylinder and central cavity of the valve. The leak can be noticed by steam escaping in a steady blow at high pressure cylinder cocks, or by removing indicator plugs on engines having relief valves on end of extension valve stems, by steam blowing through this valve. It can also be noticed by following through air valves on low pressure cylinder ports after the reverse lever has been moved from central position sufficiently to get the lap opening on valve to low pressure cylinder. If these rings do not leak, no steam should escape from these points. If rings 5 and 6 to low pressure cylinder leak, it can be noticed by a steady blow through the exhaust at the same test made for 1 and 8. If there should be a small leak through rings 1 and 8, the steam will not be entirely lost, as it goes to do useful work in the low pressure cylinder. To test rings 3, 4, 5 and 6, governing the admission and release to low pressure cylinder, place the reverse lever in full gear with starting valve open and driver brakes on, open the throttle a little, and if the rings leak, it will be indicated by a steady blow through the exhaust nozzle.

To test high pressure cylinder packing rings, place engine at about quarter stroke so that valve is open and steam enters high pressure cylinder at front end. Keep starting valve closed and driving brakes on, open throttle and admit steam. If the packing rings leak,

the steam will pass the rings and down through center of the valve to the forward end of the low pressure cylinder, and can be detected by a steady escape of steam at front cylinder cock. To test low pressure cylinder packing rings, keep engine and valves in same position as when testing high pressure cylinder packing rings, but open starting valve, which gives an increased pressure in low pressure cylinder. If the packing rings leak, it will be detected by a steady escape of steam at the back cylinder cock. The testing of valves and pistons for leaks and blows should always be done when cylinders are hot and well lubricated. Should the high presure cylinder packing blow or leak, it would increase the pressure in the low pressure cylinder. Consequently the exhaust would be heavier on this side, and sound as if the valves were out. A leak through the low pressure cylinder packing will decrease the exhaust pressure and cause the engine to have two light exhausts on that side.

STARTING VALVE.

When it is observed that the engine is going lame or exhausts unequally, the first inspection necessary would be to examine the starting valves and connecting levers. Place the starting valve in cab in central position, then note the position of the lever on the starting or by-pass valve. If this is central, that proves these valves to be exactly right. If one is central and the other side is front or back of central position, the connecting lever rod should be lengthened or shortened, as the case may be, to make it central. Also note carefully whether the plug of the by-pass valve is properly ground in the body of the valve and allows no leakage around the valve when the same is in a closed position. If any leakage of these valves is observed, the engineer should report this at the end of the trip, and the round house foreman should carefully look into the cause of the leakage, tighten up the packing gland, or re-grind the plug, as the case may be. Should the lameness still continue, a rigid inspection

of the motion work for defects, such as bent eccentric rods, bent transmission rods, loose rocker boxes, etc., should be looked for. If the motion work is in no way damaged, and the lameness still continues, it is then necessary to test the valve packing rings and cylinder packing rings.

BREAKDOWNS.

In case of breakdown caused by a broken main rod pin, crosshead or any other part of the valve or engine mechanism, disabling one side of the engine, disconnect broken side and bring in part of engine's full rating. In disconnecting this class of engine, proceed exactly as you would with a simple engine. The valve, when placed in central position, will cover all ports the same as the plain D slide valve. When the breakdown is a blown out low pressure cylinder head, broken piston rod or piston, do not disconnect the engine on that side, but proceed as follows: For low pressure cylinder head, disconnect the by-pass valve on that side and have it closed. Let the back high pressure exhaust escape through the open front low pressure cylinder to the atmosphere. Pay close attention to the lubrication of the low pressure cylinder, and do not run at a very high rate of speed. In case of a broken piston or piston rod, proceed as above with regard to the by-pass valve. Remove front cylinder head, take out piston or piston rod, or both, and in the latter case plug piston rod gland from the inside so that the high pressure exhaust in passing through the low pressure cylinder does not blow through said gland. This being done, put front head on again and proceed with your train.

FIRING.

On account of the very mild exhaust, the fireman should carry the fire as light as possible. A little practice will enable him to judge how to get along with the least amount of fuel.

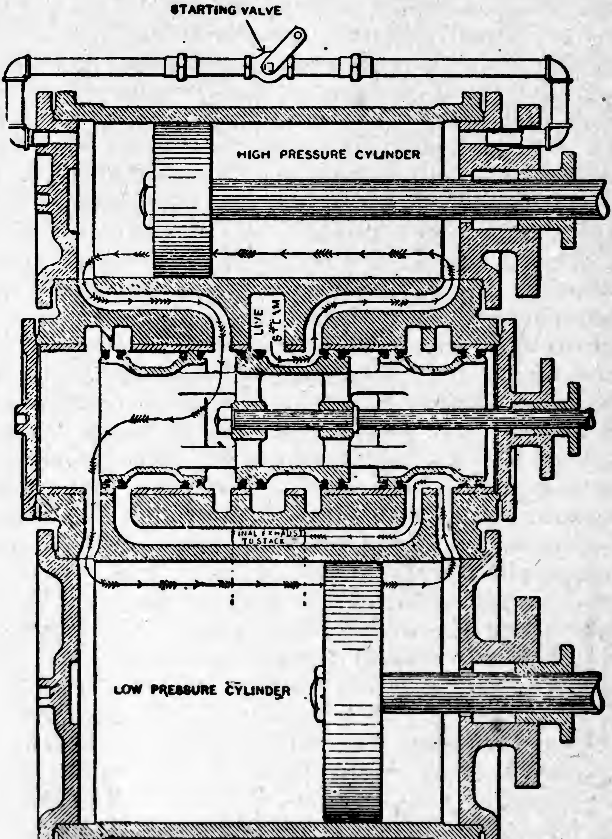
THE BALANCED COMPOUND.

In all two cylinder locomotives, whether single expansion or compound, and in four cylinder types, such as tandem and the original Vauclain compound, the reciprocating parts are counter-balanced by rotating weights in the driving wheels. This arrangement of balance becomes unsatisfactory, particularly for heavy locomotives, and when extremely high speeds are attained, by balancing the reciprocating parts against each other. The rotating balance in the wheels used to complement these parts can be eliminated, avoiding to a great extent the vertical shocks to that directly due to the weight of the locomotive. Consequently, with a self-balanced arrangement of reciprocating parts, the weight on the driving wheels may be increased without damaging the track and higher speed is attainable without undue strain upon the working parts of the locomotive. The balanced compound designed by Mr. S. M. Vauclain and built by the Baldwin Locomotive Works in 1902, is intended to accomplish these results and simplify as far as possible the arrangement of the working parts. The cylinders are a development of the original Vauclain four cylinder compound type, with one piston slide valve common to each pair. Instead of being superimposed and located outside of the engine frames, the cylinders are placed horizontally in line with each other, the low pressure and the high pressure inside the frame, and the slide valves are of the piston type, placed above and between the two cylinders, which they are arranged to control. A separate set of guides and connections is required for each cylinder. The two low pressure cylinders being inside the frames, the pistons are necessarily coupled to a crank axle. The low pressure pistons are coupled to crank pins on the outside of the driving wheels.

The cranks on the axle are set at ninety degrees with each other and at one hundred and eighty degrees with the corresponding crank pins in the wheels. The

pistons, therefore, travel in the opposite direction and the reciprocating parts act against and balance each other to the extent of their corresponding weight.

STEAM DISTRIBUTION IN BALANCED COMPOUND.



Steam Distribution in Balanced Compound Cylinders

The distribution of steam is shown in the accompanying cut. The live steam ports in this design are

centrally located between the induction ports of the high pressure cylinder.

Steam enters the high pressure cylinder through the steam port and the central external cavity in the valve. The exhaust from the high pressure cylinder takes place through the opposite steam port to the interior of the valves which acts as a receiver. The outer edges of the valve control the admission of steam to the low presure cylinder. The steam passes through the valve to the front of the low pressure cylinder or from the back of the high pressure to the back of the low pressure cylinder. The exhaust from the low pressure cylinder takes place through external cavities under the front and back portion of the valve which communicates with the final exhaust port. The starting valve connects the two live steam ports of the high pressure cylinder to allow the strain to pass over the piston.

SCHENECTADY TWO-CYLINDER COMPOUND.

This type of compound engine can be operated as a simple engine by moving the handle of the three-way

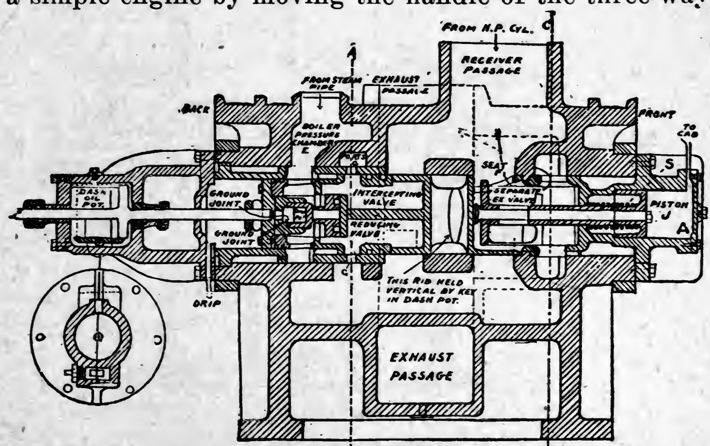


Fig. 1

cock in the cab which is moved by hand to admit air or steam into the pipe that connects with one end of

separate exhaust valve chamber A (Fig. 1), forcing the separate exhaust valve from right to left against the tension of the spring S.

When the throttle is opened steam is admitted to passage E leading to the intercepting valve, forcing the valve from left to right and allowing the steam to pass through the valve and ports G from which it passes through the reducing valve to the low pressure steam-chest. Steam is also admitted directly from the steam-pipe to the high pressure cylinder. The steam in the high pressure cylinder exhausts through the receiver and separate exhaust passage, while the steam in the low pressure cylinder exhausts in the same manner as when working in compound position. Figs. 1 and 2, are both self-explanatory, showing plainly the passage of the steam while working either as a simple or as a compound engine.

The two-cylinder compound is changed from simple to compound by returning the threeway cock to its

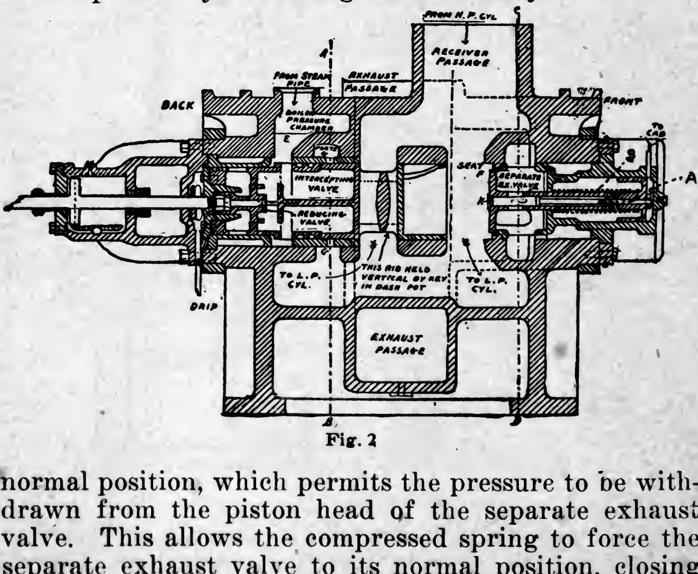


Fig. 2

normal position, which permits the pressure to be withdrawn from the piston head of the separate exhaust valve. This allows the compressed spring to force the separate exhaust valve to its normal position, closing

the communication between the high pressure cylinders and the exhaust. (Fig. 2.)

The pressure in the receiver due to the exhaust from the high pressure cylinder will force the intercepting valve to the left, which opens a passage for the exhaust steam through the receiver to the low pressure steam-chest. A movement of the intercepting valve to the left prevents the passage of live steam from the boiler to the low pressure steam-chest.

OIL DASHPOT.

The function of the oil dashpot is to insure a steady movement of the valve without shock. The dashpot should always be kept full of engine oil, as this assists the intercepting valve in maintaining a steady movement. If there is no oil in the dashpot it will permit the intercepting valve to slam, and this is the usual cause of the valve breaking.

OPERATING AS SIMPLE ENGINE.

A compound engine should be operated as a simple engine only when starting a heavy train or to keep the engine from stalling on a grade, and this never at a higher speed than four to six miles an hour. Always when starting a heavy train work the engine simple.

THE INTERCEPTING AND REDUCING VALVES.

The intercepting and reducing valves of a two-cylinder compound engine are automatically operated by the steam pressure exerted upon them this being due to the difference in the areas of the ends of the valves. If the engine stops with the high pressure side on the center and will not start when given steam, the cause is either a stuck intercepting or reducing valve, as this prevents direct communication between the boiler and low pressure cylinder. The position of intercepting valve-stem will indicate which valve is stuck. With throttle open a light blow on the end of the stem will move it ahead. Should the steam be out only a short ways it indicates a stuck reducing valve. A few sharp

blows on the back head of the intercepting valve with the throttle open will generally loosen it, and again communication will be established between the boiler and the low pressure cylinder, and the engine will start.

SEPARATE EXHAUST VALVE.

A weak separated exhaust valve spring (Fig. 2.) or a stuck exhaust valve, will cause two exhausts of air to blow from the three-way cock when changing the engine from simple to compound. If the engine will not operate in compound when pressure in the separate exhaust valve is released by the three-way cock it shows that the exhaust valve is stuck and that communication with the valve has not been closed. A little coal oil introduced through the three-way cock in the cab and forced to the separate exhaust valve, followed a little later with a little valve oil will usually release the valve.

Should steam blow at the three-way cock it would indicate a leaky separate exhaust valve-seat which permits steam to pass by the exhaust valve packing ring.

LUBRICATING CYLINDERS.

In lubricating a compound engine cylinders, about two-thirds of the oil should be fed to the high pressure cylinder while working steam and when shut off or drifting for some distance this should be right opposite the most oil going to the low pressure cylinder, and by using a little steam in drifting there need not be so much oil used. The necessity of using more oil in the high pressure than in the low pressure cylinder is on account of the higher pressure of steam in the high pressure cylinder, which causes more friction in the high than in the low pressure cylinder, besides a certain amount of the oil fed to the high pressure cylinder is carried into the low pressure along with the steam.

WATER HEIGHT.

The water in a compound boiler should be only carried just high enough to insure safety from heating

any sheets of the firebox, as wet steam is far more detrimental to a compound engine than a simple in all classes of service.

LOCATING BLOWS IN TWO-CYLINDER COMPOUND.

The locating of blows on a two-cylinder or cross compound engine depends wholly on the type of engine. The valve and cylinder packing blows and leaks are tested for much in the same way as on a simple engine, and the engine should be operated as a simple engine when testing for them. In testing for blows in the intercepting valve, place the right side of the engine on the top or bottom quarter, the reverse lever in the center notch, close the intercepting valve and open the separate exhaust valve. This will permit steam to pass through the separate exhaust valve and if the intercepting valve blows the steam will appear at the exhaust nozzle and thence out the stack.

BEFORE STARTING HAVE AIR PUMPED UP.

If air is used to operate the separate exhaust valve, it is very important that it should be pumped up before starting the two cylinder Schenectady compound, so as to insure a sufficient amount of air pressure to operate the separate exhaust valve, so as to be able to operate the compound as a simple engine.

BREAKDOWNS SCHENECTADY CROSS COMPOUND.

In case of breakdowns and it is necessary to put the engine on one side, the disconnecting can be done in exactly the same manner as for a simple engine. The main rod taken down, crosshead blocked and valve clamped central to cover all ports. In all cases, regardless of which side is disabled, the intercepting valve must be put in position to allow engine to work as a simple engine. All the different types of compound locomotives are so arranged that live steam can be admitted to the low pressure cylinder so that the power

may be increased for starting trains and to keep them from stalling on grades. This feature on the two-cylinder compound is controlled by the movement of the intercepting valve; one position of this valve permits the live steam to enter the low pressure cylinder thus causing the engine to work simple, reversing the position of this valve closes the opening for live steam to the low pressure cylinder and opens a passage that allows the exhaust steam from the high pressure cylinder to enter the receiver and then to the low pressure cylinder. The movement of this intercepting valve is at all times controlled by the engineer by a small lever in the cab, and by the movement of this lever the engine can be worked simple or compound at any part of the stroke, or at will of the engineer.

BROOKS TANDEM COMPOUND.

The four-cylinder Brooks compound locomotives are called Tandems, because both pistons are operated by the same piston rod, and the high and low pressure cylinders are one ahead of the other The high pressure being ahead and connected to the low pressure.

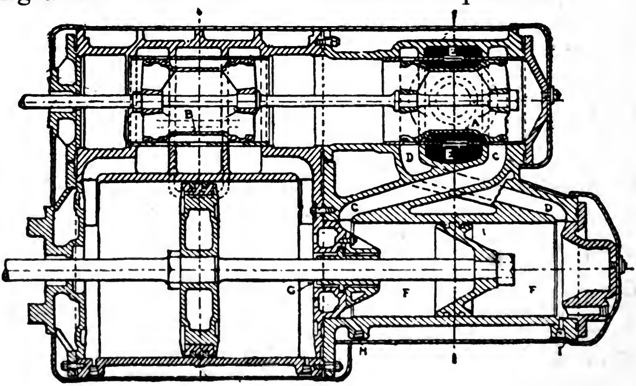


Fig. 1. Tandem Compound Cylinders

The valves used on the tandem compound are both inside and outside admission (Fig. 1). In the tandem compound engine the steam does not exhaust from the

right to the left cylinder as with the cross compound, but passes from the high pressure cylinder to the low pressure steam chest on the same side.

TESTING TANDEM COMPOUNDS.

The several illustrations shows sections through steam-chests, valves and cylinders, with valves in various positions for testing. It will be noted that high pressure valve A is inside admission, while low pressure valve B is outside admission. Also that ports C and D leading from high pressure steam-chest E to cylinder F, are crossed. Both valves A and B and cylinder packing and piston packing sleeve G can be tested on each side of engine by simply moving the reverse lever. To make tests, place the engine on the quarter on side to be tested and proceed in the following manner:

Testing High Pressure Valve, Fig. 1.—The engine on top quarter reverse lever in center notch, starting valve S closed as shown in Fig. 7. This places both valves A and B in a central position, covering all ports on side to be tested. By opening throttle, steam is admitted to the high pressure steam-chest E as shown in Fig. 1. If steam flows from either cylinder cock H or I, the high pressure valve A is blowing.

Testing Low Pressure Valve, Fig. 2.—Put engine on top quarter, reverse lever in center, as in Fig. 1. Starting valve S open as in Fig. 6. Remove by-pass valve M in Fig. 6, but replace valve cap, which is not shown as it is bolted to under side of starting valve.

This allows steam to flow through by-pass from high pressure steam-chest H through starting valve ports N and O and past exhaust edge X and Y of high pressure valve A into low pressure steam-chest P. If steam now blows from low pressure cylinder cocks K and L the low pressure valve B is leaking.

Testing High Pressure Cylinder Packing.—Put engine on top quarter, starting valve S closed as in Fig. 7. reverse lever in back motion. This admits steam from high pressure steam-chest E through steam port D to

front end of high pressure cylinder F. If steam now blows from the back high pressure cylinder cock H the high pressure cylinder packing is blowing.

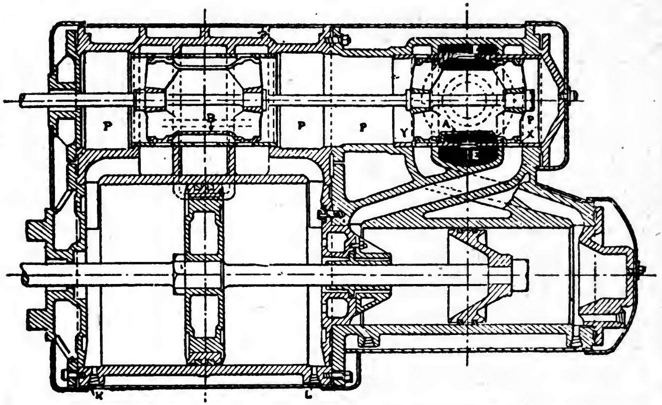


Fig. 2. Tandem Compound Cylinders

Testing Low Pressure Cylinder Packing.—Put engine on top quarter valve S open as shown in Fig. 6; reverse lever in back motion. This allows steam to flow through starting valve S into low pressure steam-chest P, then through front end of low pressure steam port R to front end of low pressure cylinder J. If steam shows at back low pressure cylinder cock K the low pressure cylinder packing is blowing.

Testing Piston Packing Sleeve between Cylinders. Fig. 5. Place engine on top quarter; starting valve S closed as in Fig. 7. Reverse lever in forward motion. This admits steam from the high pressure steam-chest E through steam port C to back end of high pressure cylinder F only. Now if steam appears at front low pressure cylinder cock L, the piston sleeve is worn and is leaking.

Fig. 6 shows starting valve open for working engine simple. Also shows section through high pressure valve, steam-chest and starting valve. By-pass valve M removed, but having the valve cap replaced, for

working simple starting valve lever T should be vertical, which places valve S in a forward position, opening both ports N and O.

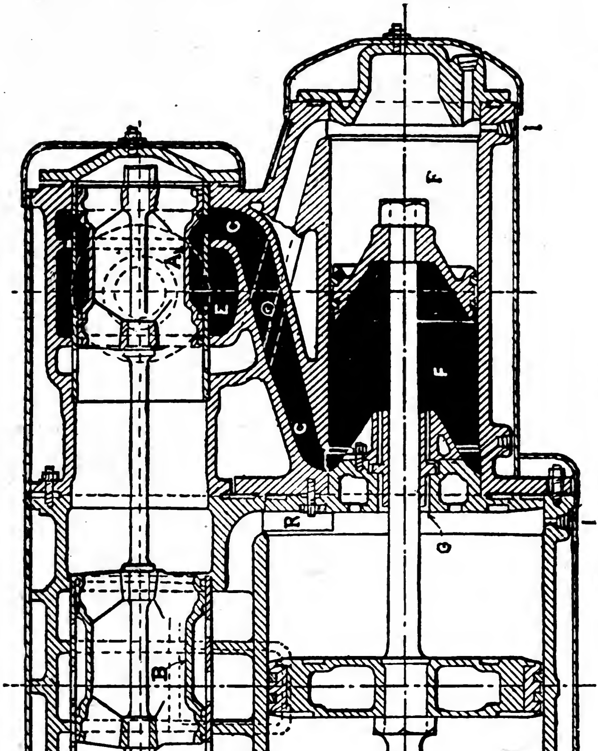


Fig. 5. Tandem Cylinders

For Figure Two Test.—The starting valve S is in the position as shown in Fig. 6, but having high pressure valve A on center and by-pass valve M removed.

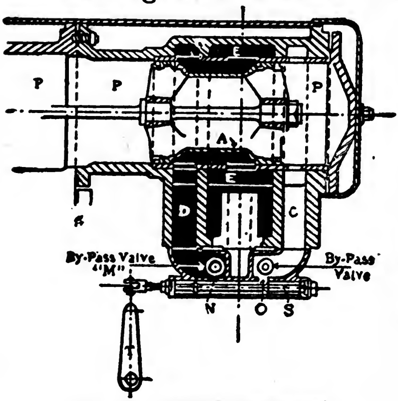


Fig. 6. Tandem Compound

For testing low pressure cylinder packing, valves A and S are in position as shown in Fig. 5, only having by-pass valve M replaced.

Starting valve in position for working compound, Fig. 7, same section as Fig. 6, both by-pass valves in place, lever T in back position, so starting valve S covers port O.

For Fig. 1. Test starting valve S as in Fig. 7, the high pressure valve A on center for testing high pressure cylinder packing, valves A and S in position as shown in Fig. 7. For Fig. 5, test starting valve S as in Fig. 7, high pressure valve A in forward motion.

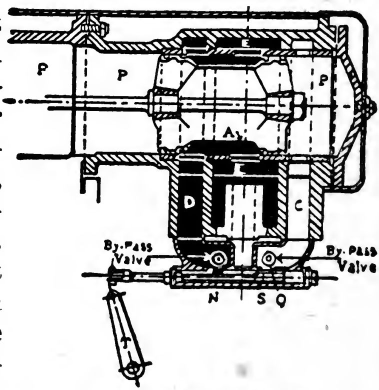


Fig. 7. Starting Valve

WORKING TANDEM AS A SIMPLE ENGINE.

To work a Tandem compound as a simple engine, the reverse lever must be in full back or forward gear. The low pressure steam chest is equipped with a reducing and starting valve, connecting with the high pressure steam pipe, and this valve works automatical-

ly, only with the reverse lever in one of its full gears. With the lever in any other position, the valve is locked to its seat by a spring, therefore it is in-operative. The combined starting and reducing valve allows the admission of steam into the low pressure cylinder at an equivalent to the maximum pressure obtained in this cylinder when the engine is working compound. As soon as the engine makes one complete revolution and the receiver is charged with the exhaust steam from the high pressure cylinder, the starting valve becomes inoperative, causing the engine to work compound. The high pressure steam port and the passage surrounding the by-pass valve have communication with the starting valve.

The starting valve which causes the engine to work simple, and which is operated by a lever in the cab, admits steam directly to the low pressure cylinder. Steam is first admitted to the high pressure steam chest through the short steam pipe connecting the saddle and steam chest, passing through the ports and around the by-pass valve, which registers with the high pressure steam ports. The by-pass valves are held to their seats by the pressure from below, which is in direct communication with the steam chest. The starting valve, having thus established communication with both high pressure steam ports, steam passes through both hollow piston valves, and is thus admitted to the low pressure cylinder.

TANDEM BREAKDOWNS.

Breakdowns on the road with the Brooks Tandem compound, should be disconnected just the same as a simple engine, the crosshead blocked and the valve used to cover the steam ports in the same manner.

OVER-PASS AND BY-PASS VALVES.

The function of the over-pass valves in the Richmond compound engine is to prevent the forming of a vacuum in the steam chest, and to keep the cylinders from overheating. When the throttle is open the

passages A-A and chambers U-U are filled with steam, as shown in Fig. 1. When the throttle is closed and the engine drifting, a vacuum forms in the steam chest, which causes a vacuum to form in chambers U-U on each side of the over-pass valves, and the valves are forced apart, which opens passage B-B from one end of the cylinder to the other, and the air, which is compressed ahead of the piston, can flow into the other end of the cylinder, as shown in Fig. 2, thereby preventing

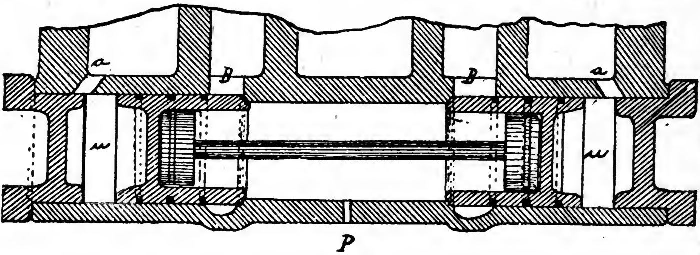


Fig. 1

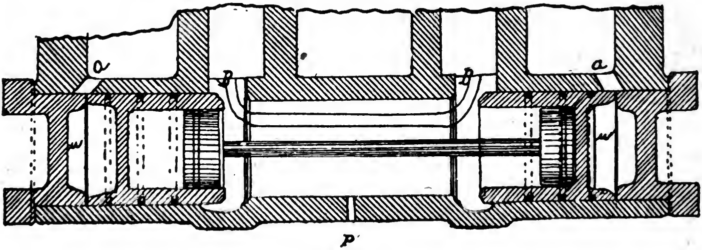


Fig. 2

to some extent the formation of a vacuum. The space between the valves is in communication with the atmosphere by the small vent P, as it was found best to admit some air to prevent the cylinders from overheating, caused by the heat generated by churning the air back and forth in the cylinders. The vent P also to some extent aids in preventing the forming of a vacuum. Over-pass valves are only used on the low pressure cylinders. The purpose of the by-pass valves, which are connected with the steam ports, is to allow

communication between the steam chest and the steam ports in the cylinders and their use is to relieve the cylinders of excessive back pressure when drifting any distance.

CYLINDER COCKS OPEN.

As there is a great deal more condensation in the cylinders of a compound engine than in those of a simple engine, therefore it is far more important that the cylinder cocks on a compound should be open when starting than on a simple engine.

USING SAND WHEN STARTING.

It is very important that the rails should be well sanded when starting a compound engine in the simple position, on account of the increased power exerted on the piston. The driving wheels are much more apt to slip than when working the engine compound.

DO NOT WORK SIMPLE.

The compound locomotive should never be worked simple for any distance or when uncalled for, as thereby is caused undue strain and wear on the valve gear, besides a wasting of fuel and water.

SHORT CUT-OFF.

It is considered better to work a compound engine at about one-half stroke, as the power of both cylinders is better equalized than with the lever in short cut-off, on account of greater compression.

STEAM HEAT REGULATING OR REDUCING VALVES

There are several different styles of pressure regulating or reducing valves used on locomotives for the purpose of maintaining a uniform pressure in steam heat lines throughout the country, but as they are all of similar construction and operation I will only take up the two in most general use, giving illustrations and construction and operation of the Gould and the Leslie pressure regulators

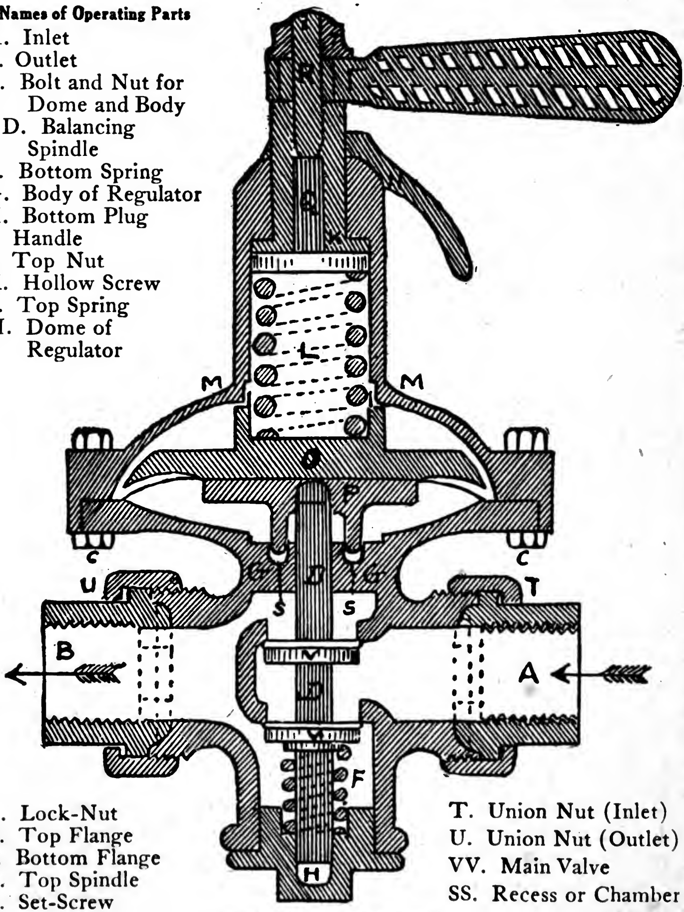
THE GOULD PRESSURE REGULATOR.

In the illustration we show a sectional view of the Gould pressure regulator and its parts.

Construction and Operation.—The Gould valve is of the diaphragm type, and is nearly a balanced valve. The diaphragm is made of thin bronze metal

Names of Operating Parts

A. Inlet
B. Outlet
C. Bolt and Nut for Dome and Body
DD. Balancing Spindle
F. Bottom Spring
G. Body of Regulator
H. Bottom Plug
I. Handle
J. Top Nut
K. Hollow Screw
L. Top Spring
M. Dome of Regulator



N. Lock-Nut
O. Top Flange
P. Bottom Flange
Q. Top Spindle
R. Set-Screw

T. Union Nut (Inlet)
U. Union Nut (Outlet)
VV. Main Valve
SS. Recess or Chamber

Gould Pressure Regulator

slightly corrugated on its outer edge, with an enlarged flange O, which assists the diaphragm in retaining its shape. The dome M of this regulator is solid, which will prevent the steam from escaping into the cab, were the diaphragm to break or become defective. The chamber shown as S S provides a water seal, that prevents a chattering of the valve.

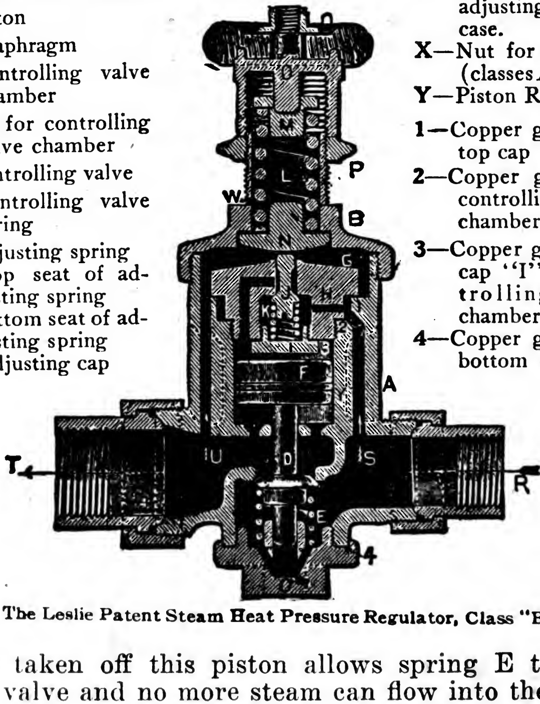
The regulator is operated or set by the handle I, which is perforated to assist in keeping it cool. The lever marked N is an extension of a lock nut, that holds the regulating screw firmly in any position that it is set at. The set screw R is provided for the purpose of a check on the maximum or minumum amount of pressure required. Spring L is controlled by set screw R. Spring F aids in guiding the spindle D D and also assists in the balancing of the valve and aids in the operation of the valve and spindle should they become corroded in any manner. Main valve V V is opened and closed by the movements of the diaphragm. The regulating spring L forces the diaphragm down, the main valve remaining open until the steam from the outlet side of the valve closes the main valve.

THE LESLIE STEAM HEAT PRESSURE REGULATOR.

The illustration and names of different parts given below will give a very clear idea of the **construction** and **operation** of this valve. The pressure is controlled as follows—Steam from the boiler enters the valve at R and passes up through port S and around valve J (which is held unseated by pressure of spring L acting on the diaphragm above it). The steam then passing down through the port shown on the opposite side to the top of piston F forcing this piston down against the pressure of the spring E and opening the main valve D. This now allows steam to flow freely through the regulator, discharging into the steam heat system at T. When the pressure in the steam heat system reaches the desired point to which the regulating valve has been adjusted by means of the spring L, a part of this pres-

sure passing up through port U acts on the lower surface of the diaphragm G forcing up the regulating or adjusting spring L by means of the bottom spring seat N. This relieves the pressure from top of valve J, which is then closed by means of spring K, thus cutting off live steam from top of piston F. The pressure now

A – Main body
B—Top cap of main body
C Bottom cap of main body
D Main valve
E--Main valve spring
F Piston
G—Diaphragm
H Controlling valve chamber
I—Cap for controlling valve chamber
J Controlling valve
K Controlling valve spring
L Adjusting spring
M --Top seat of adjusting spring
N—Bottom seat of adjusting spring
O—Adjusting cap
P Lock nut of adjusting cap
Q—Wood hand grip on adjusting cap
R—Inlet
S—Inlet port for controlling valve
T— Outlet
U—Port to diaphragm chamber
V –Port from controlling valve to piston chamber
W—Tell-tale hole in adjusting spring case.
X—Nut for cap "O" (classes A, B & C)
Y—Piston Ring
1—Copper gasket for top cap "B"
2—Copper gasket for controlling valve chamber "H"
3—Copper gasket for cap "I" of controlling valve chamber
4—Copper gasket for bottom cap "C"



The Leslie Patent Steam Heat Pressure Regulator, Class "B"

being taken off this piston allows spring E to close main valve and no more steam can flow into the steam heating system until the pressure has been reduced below the tension of spring L, which, when the pressure

has been sufficiently reduced again presses down on and opens valve J allowing steam to enter as before.

STEAM REDUCING VALVE DEFECTS.

The whole family of steam heat reducing valves are more or less subject to defects that will cause them to become inoperative. If the main steam valve is cut or the auxiliary valve gets to leaking badly, you will generally find the small spring broken that holds the auxiliary valve to its seat. If the bottom spring should be broken or missing it will allow steam to pass directly to steam heat line, or should the tension of the adjusting spring be too great in any style of valve the pressure in the heating line will also be too great.

Steam Not Passing Through Steam-Heat Valves.—Should steam fail to pass through the steam heat valves, it would indicate that there was no tension on the adjusting springs, or that they were broken, or perhaps some of the parts of the valve is missing in the spring casing, or the fault might be that no steam was being admitted to the valve from the boiler.

Remedy.—On all styles of valves but the Mason valve, you will have to take off the cap nut and take out the main steam valve then replace the cap nut and control the pressure of the steam-heat line with the throttle. When this is done great care should be taken by the enginemen to prevent the pressure in the steam-heat line from becoming excessive, as it would be liable to burst the hose connections between the coaches also danger of the pipes bursting in the coaches. With the Mason valve by removing the casing below the piston and inserting a small nut or washer in the cap and replacing the casing thereby forcing the main valve off its seat, which will allow the steam to pass all right.

COMBUSTION AND ITS PROCESS

All over the world the locomotive firemen are interested in the theory of combustion. A chemical analysis of the elements entering into combustion together with their change in form and effect during the process of combustion goes to show that a careful study of this subject will be of great value to both the locomotive fireman and engineer not only as to the economical use of fuel and abatement of black smoke, but in the saving of labor and general efficiency as well. The following questions and answers in combustion will give the average student of this subject a fairly good understanding of combustion. Its process, along with the terms used to explain it, I will arrange in the form of questions and answers, as by so doing it will be easier understood by my readers.

Question.—What is combustion?

Answer.—Combustion is a chemical union of oxygen, which forms one of the elements of the air, with hydrogen and carbon of the fuel and forms gas.

Q.—What are the elements that make up the fire?

A.—Nature of fuel, composition of air that fans the fire, character of gases formed by the burning fuel and the proper proportion of air to fuel to produce the greatest degree of heat.

Q.—What are the elements that perform the most important functions in the act of combustion?

A.—Carbon and oxygen.

Q.—Explain how they are important.

A.—Combustion results from a strong natural tend ency that carbon and oxygen have for each other.

Q.—What is the result of their combining?

A.—Violent evolutions of light and heat.

Q.—What is carbon?

A.—The fuel.

Q.—What is oxygen?

A.—The supporter of combustion.

Q.—Where is the oxygen drawn from?

A.—The atmosphere.

Q.—Is there anything else formed as the result of this combination of carbon and oxygen?

A.—Yes, hydro-carbon.

Q.—What is hydro-carbon?

A.—A volatile substance which burns with a lurid flame and supplies the ingredients of coal gas.

Q.—Is it important to perfect combustion?

A.—Yes, most important. Escaping at the top of the fire. Admission of air is very necessary to prevent losses of heat.

Q.—What is hydrogen?

A.—A gas which in combustion with oxygen produces water. An elementary gaseous substance very inflammable and the lightest of all known substances.

Q.—What is the atmosphere composed of?

A.—Oxygen and nitrogen principally.

Q.—Does nitrogen promote combustion?

A.—No, but it passes into the furnace and has to be heated up to the same temperature as the other gases.

Q.—What is the amount of heat necessary to raise one pound of water one degree (Fahrenheit)?

A.—One heat unit.

Q.—What is meant by heat unit?

A.—It is equivalent in mechanical energy to the power required to raise 772 pounds one foot high.

Q.—How many heat units does a pound of good coal burned produce?

A.—14,500 heat units.

Q.—What takes place when the air is drawn through the fire?

A.—The air strikes the glowing fuel. The oxygen separates from the nitrogen and combines with the carbon of the coal.

Q.—What are the proportions necessary to produce carbonic acid gas?

A.—One atom of carbon to two of oxygen.

Q.—What is the result if the oxygen is restricted?

A.—An inferior gas called carbonic oxide gas.

Q.—Which gives the best results? Explain the difference.

A.—One pound of carbon uniting with oxygen to form carbonic acid gas generates 14,500 heat units or sufficient to raise 85 pounds of cold water to boiling point, on the other hand one pound of carbon uniting with insufficient oxygen forms carbonic oxide gas generating only 4,500 heat units, the same quantity of coal being used in each case.

Q.—What amount of air has to pass through the grates of a locomotive to supply each pound of coal burned?

A.—Twenty pounds of air.

Q—How much space does one pound of air occupy?

A.—Thirteen cubic feet of space.

Q.—What is the effect of having a thin fire or holes in the fire?

A.—The gases pass in below the igniting temperature and go away unconsumed, chilling the flues and other surfaces.

Q.—What is the effect of a small blast on the fire?

A.—The gases pass through the flues at a high velocity, not allowing sufficient time for the heat to be imparted to the water in the boiler. It also causes back pressure in the cylinders, reducing the power of the engine.

Q.—If not enough air is admitted, what is the result?

A.—A gas of inferior heating power will be generated.

Q.—If too much air is admitted, what is the result?

A.—Too much air means increased draft and this prevents the flues and sheets from abstracting as much heat as they would if the speed of the gases were slower.

Q.—What is the difference between anthracite and bituminous coal?

A.—Anthracite is a hard coal and contains 90 per cent of pure carbon. Bituminous is a soft coal and contains 65 per cent of carbon and 25 per cent of hydrocarbon.

Q.—What are the proportions of hydrogen and oxygen to promote perfect combustion?

A.—Hydrogen, two pounds; oxygen, sixteen pounds.

Q.—What is learned from lessons on combustion?

A.—That to obtain the best results from coal burning in locomotives it is necessary to maintain only sufficient fuel on the grates demanded by the work that the engine is doing, to always have the grates well covered, to fire light and often, to keep the fire bright and clear, to maintain the highest temperature in the fire box so as to burn the volatile gases, which would otherwise pass away as smoke. A thick, smoky fire wastes a great part of the heat because the heat rays cannot strike the heating surfaces, hence the importance of keeping the flues, flue sheets and spark arresters clean. It is also important that the grates should be properly regulated. The brick arch is a valuable aid to economical combustion. I will give below a rule for esti mating the heating surface of a boiler.

TO FIND THE HEATING SURFACE OF A BOILER.

Add together the area of the two side sheets, the area of the crown sheet, the area of the door sheet, the area of the back flue sheet, all in square inches. To the sum thus obtained add the product of the circumference of one flue in inches, multiplied by the number of flues in the boiler, and again by the length of the flues in inches. From the total obtained subtract the area of all the flue holes in back of the flue sheet, and divide the remainder by 144. The result will be the number of square feet of heating surface in the boiler.

POINTERS FOR FIREMEN.

In firing soft coal, do not carry over six to ten inches of fire on the grates of the fire box, keep the sides and corners a little higher, aim to fire in the corners and sides more than in the center. If the boiler will not steam well with a light fire, more air is probably needed at the front of the box. Leave the fire door

open a little way for a few seconds after putting in the coal. It helps to consume the smoke. Two or three shovelsful is enough at one time if put on the bright spots. No boiler will steam well with the fire box and flues full of smoke. If you have occasion to use the hook, be careful not to mix the green coal with the partly consumed. Do not use a slash bar if it can be avoided, and be careful not to get green coal on the grates. If the box has an arch, keep a good open space between the arch and the fire. If you have a heavy train you will need to keep a heavier fire than with a light train and fast run. Always make calculations to fire according to train and speed. Hook out all clinkers from the fire as soon as you find them and get a chance. Do not fire oftener than necessary when injectors are on full. If the engine has ash pan dampers use them when necessary. If there is more steam than needed, the dampers should be closed; a certain amount of air is necessary to make a fire burn as it should. If too much air is admitted, the gases will be chilled. If too little, they will not ignite. No rule can be made for the exact amount of air required because different kinds of coal require different quantities of air. Only keep a light fire low in the center of the fire box where the most air is needed, and watch when the greatest flame appears in the fire box with the least smoke going out of the stack. Attend to the fire often and do not use lumps larger than a goose egg. Keep the ash pan clean or you are liable to burn your grates out. If firing an engine pulling a passenger train, on approaching a stop station, as soon as the throttle is closed, put the blower on lightly and open the fire door about half an inch. It helps get rid of the black smoke. When nearing the end of the trip, let the fire burn down low. Do all you can to help the engineer, but do nothing without first knowing that he wishes it done. Keep all tools and oil cans clean and filled, and be ready and willing to aid him. Try to learn what he does and how he does it, trying to anticipate his wishes, and always remember that work cheerfully

and willingly done is well done, and the chances are you will make a success of the business.

FILLING UP IN FRONT ENDS OF LOCOMOTIVES.

It is a well known fact that in odd cases engines that are equipped exactly the same as to front end arrangements as other engines, often fill up with cinders in the front end and cause more or less annoyance on the road and in doing washing out. This may be charged to some part or all of the front end appliances. Ordinarily, if an engine fills up in the front end, it is also a fact that she burns her fire hardest on the front part of the grates. The remedy for either is to lower the diaphragm a little at a time until the trouble is remedied. If the diaphragm is all in behind the exhaust and steam pipes, it may not be possible to lower it enough to clean the front end entirely and yet have the engine steam, but if such is the case a few cinders in the front end does no harm and will cause no particular trouble if left there. Sometimes the trouble may be found in the adjustment of the petticoat pipe. It should be in perfect alignment with the stack and the exhaust pipe. Then again a leak in the top or bottom joint of the exhaust pipe or any of the steam pipe joints may cause the trouble, and the engine will not steam, unless perhaps the nozzle is made very small. Filling up in the front end is not often a cause; it is usually an effect of some other trouble.

ENGINEMEN'S DUTIES BEFORE LEAVING TERMINAL.

The enginemen should arrive at the engine house in plenty of time to get the engine ready for the trip. After learning what engine is assigned to the run, they should examine the bulletin board, on which are posted all important and special notices. The first duty on arriving at the engine is to ascertain the amount of water in the boiler and condition of the fire. There should be at least two gauges of water and the fire should be even over the grates and burning brightly

and free from clinkers and ashes and not too heavy. None of the flues should be stopped up nor should there be any leaks in them or the fire box. After knowing that the necessary tools and supplies are on the engine, the next duty of the fireman is to get the fire ready to start the trip, and see that the grates and ash pan are in proper condition, and be sure there is a full supply of coal, sand and water. Before starting from the terminal the fireman should compare his watch with the engineer's. He should also insist upon reading all orders and special instructions and should read all bulletins pertaining to train movements. It is the duty of all enginemen and trainmen to understand and obey all instructions issued for their information. The engineer might overlook the fulfilling of an order, which would not happen if the fireman should call his attention to such orders at the proper time. He should also know about all meeting and passing points so as to be able to handle his fire accordingly, thus saving fuel, water and labor.

THE SOUTHERN LOCOMOTIVE VALVE GEAR.

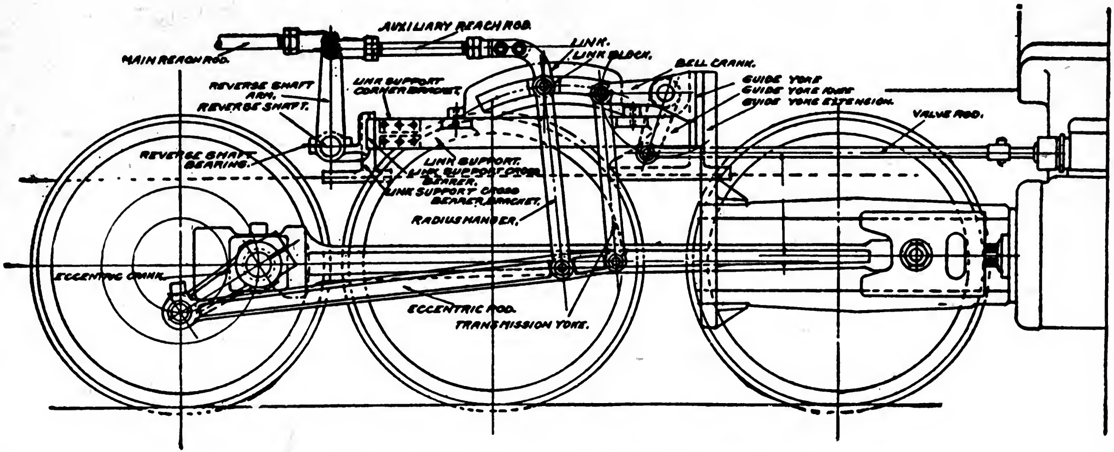
As the Southern valve gear is comparatively a new step towards simplifying and reducing complications of this most important feature of the locomotive, and as this gear is fast getting a strong hold on the lately constructed motive power of a great many of the railroads throughout North America, perhaps a short description of it along with the breakdowns and principle of its operation will be of some value and perhaps a little benefit to my readers. It should be known that it was designed and invented by a locomotive engineer by name of Mr. W. S. Brown, of the Knoxville Division of the Southern Railway, hence its name Southern Locomotive Valve Gear. While it is a radical departure from most all earlier outside valve gears, it is a gear that can be easily applied to any class of locomotive, either outside or inside admission valves, or to locomotives in any class of service, including passenger, heavy freight or yard, and is designed with the view of reducing, if not of entirely eliminating, a great many running repairs and delays to motive power chargeable thereto. It is a pretty well known fact amongst motive power men that there is generally a derangement of the valve movement in nearly all radial valve gears, mostly due to the change in the angularity of the main rod as the engine settles. The Southern gear has been designed with the view to the elimination of this most objectionable feature.

Transferring from a rotary motion to a reciprocating motion is accomplished by direct movements and on straight lines, thus doing away with strains and distortions found in most other valve gears in use today. The links with this gear being located in a horizontal position and stationary, almost entirely does away with the usual wear at this point, as the block only moves in the link, when the reverse lever is moved to adjust the cut-off or to reverse the motion of the gear. The link

being stationary, also does away with what is known as the slip of the link block, generally found in most outside or radial gears, therefore there are but sixteen possible points of wear on both sides of the engine equipped with this gear, which is less than half contained in other gears now in use. It is claimed that this gear will practically do away with engine failures chargeable to breakage of the valve gear parts. The parts are so balanced as to reduce the wear on pins and bushing to almost a minimum. The forward end of the eccentric rod is so supported by a bell crank hanger which has at its top two bearings placed so widely apart that it almost absolutely does away with any side-play or slap on the eccentric rod.

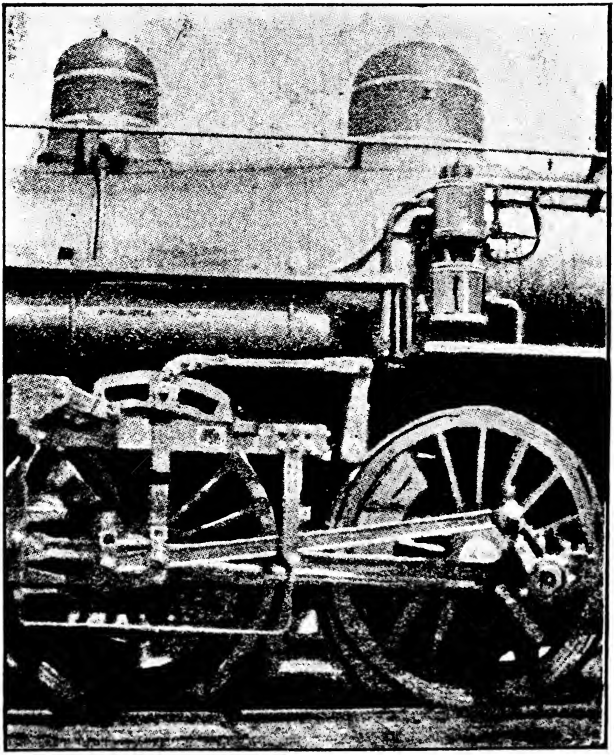
This valve gear is also designed so that it relieves the stress and strain on the reverse lever and reach-rod connections. The reverse lever handles easily while engine is working under full steam pressure, and this feature strongly appeals to the engineer as it enables him to regulate his cut-off without fear of the lever getting away from him and often induces him to work the engine at short cut-off, thereby resulting in the saving of fuel. This valve gear stands up well under the stress of hard usage that it is sure to get in heavy freight service, as has been repeatedly proven by a series of dynamometer car tests. The Southern valve gear has been applied and is now in use on a large number of railroads throughout this country, and all roads using the motion are generally well pleased with results obtained as the simplicity of the motion, the very few wearing points, the quick action of the valves, and the fact that the gear remains in service between overhaulings with practically no expense to the motion work, makes this almost an ideal gear for all classes of service.

We herewith show a clear cut of the Southern valve gear, giving the names of the different parts and the manner in which they are connected. This gear is what is known as the radial type and gets all of its motion from an eccentric crank attached to the main crank pin.



Names of Southern Locomotive Valve Gear Assembled.

The gear differs materially from other outside radial type gears, in that it has no cross-head connections, and that the link is stationary and is placed in a horizontal position instead of vertically. However, the duties of the link are exactly the same as in any other gear, in that it enables the motion to be reversed and by movement of the reverse lever regulates the variation of the cut-off as desired, (as can readily be seen by referring



Southern Valve Gear as Applied by Baldwin Locomotive Works.

to the illustration). The rotation of the eccentric crank causes a forward and back as well as an up and down

motion of the front end of the eccentric rod where coupled to the connection termed the transmission yoke. This motion is transferred to the bell crank, causing the rear arm of the bell crank to move up and down, producing a forward and back motion to the lower arm of the bell crank, to which the valve stem is connected. The movement of the reverse lever produces the same results with this gear as with any other, that is, when the lever is placed in full forward motion, thereby placing the link block at the extreme end of the front end of the link. The movement of the bell crank is increased proportionately, thus giving the full travel of the valve, as the reverse lever is moved back, carrying the link block back with it. The motion is gradually decreased, thus shortening the travel of the valve. When the lever is in the full back motion with the engine on either quarter the positions of the valve is reversed, the same as with any other motion, thus reversing the motion of the engine.

The main feature of this gear is its extreme simplicity, and the fact that owing to the manner in which it is connected a full port opening can be obtained with only $2\frac{1}{2}$-inch piston travel, while with other radial type gears the piston must travel $4\frac{1}{2}$ to 5 inches before a full port opening is obtained.

BREAKDOWN AND REMEDIES AS APPLIED TO THE SOUTHERN VALVE GEAR.

Insofar as breakdowns are concerned the builders claim that this gear is not liable to failure. However, there is nothing built in the shape of a locomotive that cannot fail, consequently there may be times when by the loss or breaking of a pin or one of the parts it would be necessary to disconnect, as can be seen by the illustration, all the motion is obtained from the eccentric crank. Therefore, should this crank or eccentric rod break, the engine would be totally disabled on the

broken side. In fact it would appear that as the motion of the valve is dependent altogether on a single source, the failure of any part of the gear would put that side of the engine out of commission. But in a case of that kind the fact remains that there would be very little to disconnect, and following I am giving remedies for possible breakdowns that might occur with this gear:

BROKEN CRANK OR ECCENTRIC ROD

Disconnect eccentric rod from crank, radius hanger and transmission yoke, tie up hanger and yoke, clamp valve central on seat and proceed.

BROKEN RADIUS HANGER.

Disconnect the hanger from rod, take down eccentric rod, clamp valve in central position and you are ready to go.

BROKEN TRANSMISSION YOKE.

Disconnect from the eccentric rod, and clamp valve centrally and you are ready to proceed.

BROKEN HORIZONTAL ARM OF BELL CRANK.

Disconnect the yoke from the eccentric rod, tie up to clear, clamp your valve in center position and proceed.

BROKEN VERTICAL ARM TO BELL CRANK.

Clamp the valve in central position and take the arm down if liable to strike and you are ready to go.

BROKEN AUXILIARY REACH ROD OR REVERSE SHAFT ARM

Place reverse lever in position so as to give port opening enough to start and handle train over all

grades, then block both links; placing blocks in both links in that position and control speed of train by main throttle and proceed.

BROKEN MAIN REACH ROD, OR MIDDLE ARM TO REVERSE SHAFT.

Block link blocks in full valve travel, controlling power and speed with the throttle and proceed.

BOTH AUXILIARY REACH RODS BROKEN.

Block link blocks in full valve travel, throttling steam to control power and speed of engine and you are ready to go.

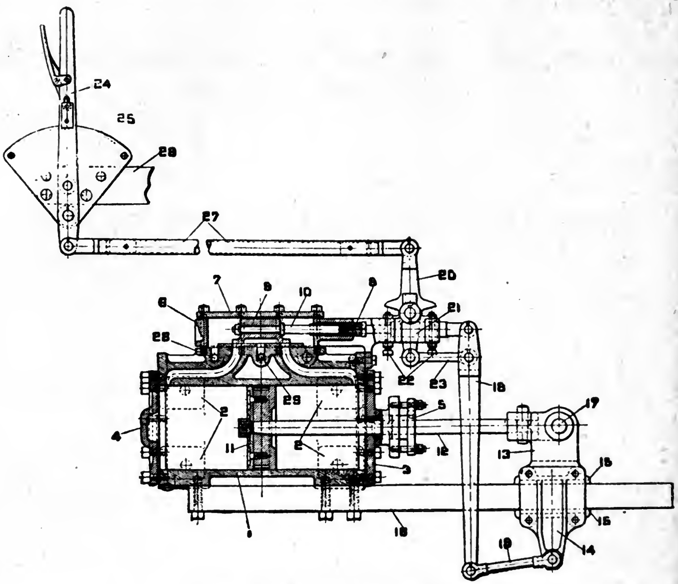
TO LUBRICATE VALVES WHEN VALVE IS CLAMPED CENTRAL.

If indicator plugs are provided remove them and lubricate through openings. If no plugs, would slack off on cylinder head and secure the head in a position so could lubricate that way if necessary.

THE RAGONNET POWER REVERSE GEAR.

With reference to the accompanying illustration the parts of the Ragonnet reverse gear are designated as follows: 1, cylinder; 2, cylinder support; 3, cylinder head, front; 4, cylinder head, back; 5, cylinder gland; 6, valve chest; 7, valve chest cap; 8, valve chest gland; 9, valve; 10, valve stems; 11, piston; 12, piston rod; 13, crosshead; 14, crosshead plate; 15, crosshead gibs; 16, crosshead guide; 17, reach rod connecting pin; 18, floating lever; 19, floating lever link; 20, rocker; 21, valve stem guide; 22, safety-stop set screw; 23, connecting link; 24, reverse lever; 25, reverse lever support and quadrant; 26, reverse lever bracket; 27, reverse lever

connection rod; 28, air inlet; 29, exhaust port. It's operation is as follows: The gear is preferably operated by



Ragonnet Power Reverse Gear.

air, although an auxiliary steam connection is provided. Distribution is regulated by an ordinary D slide valve, arranged for outside admission. The piston rod is connected to a crosshead, which is coupled to the reverse shaft by means of a reach rod. The crosshead gibs are held in place by a cast steel plate having an arm projecting downwards. This crosshead arm is connected by a link with the lower end of a floating lever. The upper end of this floating lever is pivotly connected to and supported by the valve stem, which in turn is carried by a cylindrical guide, through the agency of a rocker, the upper end of which is connected by a light rod with a small reverse lever, and the lower end through a link with the floating lever a short distance below the valve stem.

The movement of the valve is controlled from the cab, the rocker is provided with tappets which strike the ends of projecting set screws when the limit of travel of the valve is reached. These set screws require no adjusting after the gear is properly applied, and merely limit the throw of the reverse shaft arm in either direction. The small reverse lever is locked in any desired position by an ordinary toothed quadrant. Assuming the lever in mid-position and the valve normally covering both ports, when the lever is moved into forward gear the floating lever swings about its lower end as a fulcrum, and the slide valve is moved to the right, admitting air to the left hand end of the cylinder. The piston now moves to the right and the floating lever, pivoting about its intermediate, or reverse-lever connections, returns the valve to its central position unless the progressive movement of the reverse lever is continued. Thus it will be seen that when the lever is shifted to any desired position the piston moves in the proper direction until the valve gear reaches a corresponding point, whereupon the valve is automatically returned to its central or lapped position.

Since the exhaust, or inside lap of the valve is materially greater than the outside lap (which is very small) air is held on both sides of the piston at the same time. It will thus be seen that the mechanism is prevented from creeping or vibrating by an elastic cushion, formed by compressing the air in one end of the cylinder or the other. In no case does the valve open to exhaust when holding the gear in any desired cut-off position. Owing to this arrangment the gear is very economical of air—in fact, when piston and piston rod packing is properly maintained, the loss of air when holding the valve gears in a fixed position is practically none. The holding of the valve gear through the medium of an air cushion, instead of by a rigid latch and quadrant materially lessens the wear and tear of the valve gear and its connections.

The cylinder is oiled by means of a small lubricator placed in the cab, and suitable means of lubrication are

provided on all moving parts. Following are the instructions for operating and maintaining this gear:

POINTERS FOR THE ENGINEER

USE AIR FOR OPERATION.

See that valve admitting air from main reservoir or supply pipe is wide open at all times, except in emergency cases. Use steam only in emergency cases.

In case of pump failure, open turret valve, admitting steam to gear. The check valve in the air line will prevent steam flowing into main reservoir, but globe valve must also be closed.

Always report having turned steam on reverse gear, so that the cylinder packing may be given attention.

Always use engine oil in cylinder cup, fill at least once each trip. In case of blow from exhaust, try one or two cups full of signal oil, then work the gear rapidly back and forward.

Keep piston rod packing set up tight, do not allow any blow at this point as it may cause the gear to creep.

Always look at air gauge before moving engine. If pump has been shut off, see that full reservoir pressure has been regained before opening main throttle.

DEFECTS OF THE REVERSE GEAR.

When gear is reported creeping, examine and test cylinder packing, and slide valve also. See if piston rod packing is tight. Both valve and piston may be tested by taking off cylinder head and blocking crosshead against opposite head. Then place reverse lever in the corner which will admit air to end of cylinder next to crosshead. A blow from valve will be felt by holding hand under port where it enters top of cylinder. A blow past cylinder packing may be detected by feeling around the circumference of the piston.

When gear is reported as blowing from exhaust, examine and test cylinder packing and slide valve. See

that valve is free on stem. Nut on end of stem should be so adjusted that valve is free, with as little lost motion as possible.

When fitting new cast iron piston rings to cylinder, use care in filing joints to match. Instead of allowing opening in joints, fit tightly so that piston is easy driving fit in cylinder. When soft cylinder packing is used, apply at least three rings of $\frac{5}{8}$-inch square. Garlock braided asbestos, or Johns-Manvill Vulcabeston "Mallet quality" A $\frac{1}{4}$ boiler plate rings outside diameter equal to follower, inside diameter such as to slip over piston should be used back of packing.

When engineer reports having turned steam on gear, cylinder packing should be tested before engine goes out again. After examining or renewing cylinder packing **grease rings and cylinder** with soft grease or valve oil. The set screws opposite tappets on valve stem rocker are not to be tampered with unless the stroke of the gear needs changing.

When stop pins are used in guide, gear must be so adjusted that crosshead will not touch pins while pressure is turned on. **An easy way to remove piston from cylinder,** disconnect reach rod and piston rod, place hard wood block over end of piston rod, and use crosshead for a hammer.

LIST OF QUESTIONS AND ANSWERS

FOR

Promotion of Firemen and Employing of Engineers.

This list of questions and answers is made up from the manuals in use for the examination of firemen and engineers by a large number of the leading railroads of the country and partly by the author. It should be borne in mind, however, that the wording of the answers is not as a rule considered of much consequence as long as the candidate shows that he understands the subject and any engineer or fireman who can give an intelligent answer to the majority of these questions is very liable to obtain the position he seeks, or pass his examinations for promotion. The form of the question is not always the same, the wording often being different, but when stripped of all surplus words mean the same and are susceptible to the same answer and the examiner as a rule makes sure that the candidate has not merely committed the questions and answers to memory, but that he really and truly understands the various matters they cover, and I would urge all interested parties to read and study carefully the contents of this little book upon the various subjects to which the following list pertains, as this list is designed to cover most any examination in use on railroads throughout the country, including the three years' progressive examinations being used by a number of railroads.

FIRST YEAR.

Questions and Answers.

Question—1. Do you consider it essential to your success in business to abstain from the use of intoxicating liquors? Do you consider it is to your interest to

work to the best of your ability for the interests of your employer and be economical in the use of fuel and supplies?

Answer—Yes, sir, I do.

Q.—2. What are the fireman's duties at engine house previous to going out on a locomotive?

A.—See that fire is clean. Should try grates and know that they are O. K. Should see if flues or sheets are leaking, and if so call the engineer's attention to the fact. He should know that the proper tools are on the engine, *i. e.*, scoop, shakebar, hoe, rake, etc. Also flags, fuses, torpedoes and lights of proper color; should know he has plenty of coal and a full tank of water. Then get his fire in shape and assist the engineer.

Q.—3. Is it your duty to compare time with your engineer and should you insist on seeing all train orders?

A.—It is a good plan, and on most roads according to rules for firemen to compare time with engineer, also to read and understand train orders and messages. Also quite essential for a man's own safety.

Q.—4. In brief, what are the various rules pertaining to signals as found in the book of rules and regulations of the operating department?

A.—The book of rules in use on the road on which candidate works should be consulted for answer to this question.

Q.—5. In addition to any that you have not mentioned, what else do you consider a danger signal?

A.—Any unusual signal, or the absence of a signal usually displayed till investigated and understood.

Q.—6. Explain the principle of the Steam Gauge.

A.—A steam gauge consists of an elliptical shaped tube which is curved in the form of a circle. To its end are attached a lever and ratchet connected to a pointer on a dial marked to show the pressure. When pressure is put on this elliptical tube it has a tendency to straighten it out. The more pressure the more the tube will straighten, and as the tube moves the pointer will go

with it showing by numbers on the dial the amount of pressure on the tube.

Q.—7. What pressure is indicated by the steam gauge? What is meant by atmospheric pressure?

A.—The steam gauge shows boiler pressure above ordinary atmospheric pressure. Atmospheric pressure means the pressure that surrounds all things on the earth uniformly, and is the weight of the air and is 14.7 pounds per square inch.

Q.—8. What is the source of power in a steam locomotive?

A.—Heat stored in steam.

Q.—9. What quantity of water ought to be evaporated in a locomotive boiler to the pound of coal?

A.—Scientists claim from 12 to 14 pounds of water to 1 pound of coal burned, but in locomotive service an evaporation of from 4 to 9 pounds of water to 1 pound of coal is all that is obtained.

Q.—10. What is steam, and how is it generated?

A.—Steam is water changed from its liquid form to its gaseous form through the medium of heat.

Q.—11. At what temperature does water boil?

A.—Water boils at 212 degrees as shown by Fahrenheit thermometer.

Q.—12. What is the temperature of the water in the boiler when the pressure is 200 pounds?

A.—387.7 degrees Fahrenheit, while water boils at 212 degrees when there is no pressure on it, but when pressure is put on it, it takes greater temperature to cause it to boil. In boiling the bubbles of steam formed at the bottom of the water will rise at once to the surface, but under pressure the temperature must be greater, therefore under a pressure of 200 pounds it takes a temperature of 387.7 degrees before it boils.

Q.—13. What is combustion?

A.—Combustion means burning. To burn anything illustrates the process of combustion. (Theoretical definition). It is the rapid chemical combination of any substance with oxygen.

Q.—14. What is the composition of bituminous coal?

A.—Bituminous coal is principally composed of two substances known as carbon and hydrogen. These being the fuel elements or parts of the coal. There are also found small parts of sulphur, iron and moisture and dirt, slack and slate; as to the amount of the different elements depends on the quality of the coal.

Q.—15. What is carbon? From what is oxygen obtained?

A.—Carbon is an elementary substance found in nature in large quantities along with many other substances and in elementary state in several different forms such as coke, graphite or plumbago. Diamonds are all different forms of pure carbon. Oxygen is obtained from the air.

Q.—16. What per cent. of oxygen is in the atmosphere?

A.—About 23 per cent. of the air by weight and 20 per cent. by volume is composed of oxygen.

Q.—17. Is air necessary for combustion?

A.—Yes, very, as the substance to be burned must have oxygen to cause burning, and as air is where we get oxygen, it is very necessary.

Q.—18. About how many cubic feet of air is necessary for the combustion of a pound of coal in a locomotive fire box?

A.—There is such a variation in the quality of coal used that it would be hard to say. Scientists tell us 150 cubic feet of air will, or about, burn one pound of coal, but taking grade of coal and conditions of average engine from a rational standpoint, it would take about 250 feet of air to burn one pound of coal.

Q.—19. How many cubic feet of air, therefore, would be necessary for the burning of a "fire of four scoopfuls," assuming each scoopful to weigh ten pounds?

A.—Four scoops of ten pounds to each scoop would be forty pounds, and as it takes 250 cubic feet to burn one pound, multiply 250 by 40, which gives us 10,000

cubic feet of air to burn four scoops of coal, weighing 10 pounds each.

Q.—20 Why is it necessary to provide for combustion a supply of air through the fuel in the furnace?

A.—The fuel must combine with oxygen to burn, there being an unlimited supply of oxygen in the air. The air must be drawn through the fire in sufficient quantities to supply the necessary amount of oxygen for the proper burning of fuel.

Q.—21. How can you prove that it is necessary to supply air to the fire box for combustion?

A.—Easily, by closing the dampers and shutting off the draft on the fire, which will almost entirely stop burning as can be noticed when a fire is banked, as all drafts are then shut from the fire as far as possible, and it only lays and smolders till draft is again supplied.

Q.—22. What is the effect on combustion if too little air is supplied through the fire? If too much air is supplied?

A.—The fuel is only partly burned as is shown by the great amount of smoke and gases passing out of the stack, smoke and gases being to a great extent unburned fuel. If too much air be supplied it will cool down the temperature in the fire box so that, while there is plenty of oxygen there is not the necessary temperature for combustion to take place, and the gases will also pass out the stack unburned, although in many cases there will be very little black smoke.

Q.—23. What effect on combustion has the closing and opening of dampers?

A.—The dampers regulate the supply of air to the fire and by opening or closing, too much or not enough will be supplied to the fire.

Q.—24. How is a draft created through the fire?

A.—By the exhaust steam passing through the nozzle in the front end. This exhaust steam in its passage to the air drives with it the air and gases in the front end creating a partial vacuum there. With a tight front end the only way this vacuum can be supplied is by the

air passing through the ashpan fire and flues to the front end. The exhaust being continuous when engine is working produces a constant draft on the fire.

Q.—25. Describe a blower and its use and abuse?

A.—A blower consists of a pipe leading from the steam space of the boiler in the cab (generally) with a valve for turning on or off as may be wanted, and the end in the front end or smoke box is turned so that when steam passes through it will pass up through the stack. In this manner a draft can be produced on the fire when the engine is not working steam. The blower should only be used when the engine is shut off to keep the fire burning brightly or to maintain or increase the pressure. It should not be used while steam is being used or when the fire is being cleaned or dumped only as much as necessary.

Q.—26—What effect is produced by opening the fire box when the engine is being worked?

A.—It allows cold air to enter the fire box above the fire instead of through it, reducing the draft in the fire sometimes in quantities large enough to almost stop the combustion and has a tendency to cause leaky flues. It may do good if admitted in small quantities as it will mix with the gases and aid in burning them, thereby doing away with some black smoke.

Q.—27. What bad effect?

A.—The answer to question 26 will also answer this.

Q.—28. In what condition, therefore, should the fire be in order that the best results may be obtained from the combustion of coal?

A. With properly drafted engines a light. level. brightly, burning fire gives the best results.

Q.—29. What is the effect of putting too many scoops of coal on a bright fire? Is this a waste of fuel?

A.—Too much fuel to a fire at one time has a tendency to reduce the temperature in the fire box below the burning point, thereby stopping combustion until the over supply of fuel has been heated to the burning

point. During the time the heat in the fire box has driven off the gases of the coal and the draft has pulled them out the stack, causing the engine to lag in steam, if not fall back, also causing the waste of the unburnt gases that went out the stack.

Q.—30. What effect has the fire on a scoopful of coal when it is placed in the fire box?

A.—When a scoopful of coal is put in the fire box the heat of the fire drives off the volatile gases from the coal, leaving the fixed carbon or coke behind on the grates. The gases that are driven off will combine with the air and burn if the proper temperature is there, but if not they will pass off unburned. These gases are colorless if properly burned, but without enough air they will only partly burn and the part that does not burn will be in the form of soot or fine particles of carbon which form black smoke, the coke staying on the grate till enough air is supplied to burn it.

Q.—31. In what condition should the fire be to consume these gases?

A.—The fire must be hot enough so that the necessary temperature for the burning of these gases is present, also thin enough so that there is air enough to mix with and burn them.

Q.—32. What is the temperature of the fire when in this condition?

A.—It must be above 1,800 degrees Fahrenheit and the temperature can be fairly judged by the appearance of the fire. A bright red fire is just about that temperature.

Q.—33. How can the fire be maintained in this condition?

A.—A fire of this kind can best be maintained by having it properly built to start with, by keeping it level and not too heavy, and by firing light and often. Have the coal well broken up and spread the coal on the bright spots and keeping the fire box door shut be-

tween each shovelful, only adding fuel as often as necessary to maintain the required pressure.

Q.—34. What is black smoke? Is it combustible?

A.—Black smoke is exhaust steam from the engine, colored by the unburnt carbon passing off of the coal. Yes, to a great extent, under favorable circumstances.

Q.—35. Have you made any effort to practice the smokeless method of firing?

A.—Yes, and it saves labor and fuel and reduces the amount of black smoke.

Q.—36. How can black smoke be avoided?

A.—By having engine properly drafted and not worked beyond its capacity. By having a good quality of fuel. By having the fire in good shape to start with, and keeping it so by careful firing.

Q.—37. Can the firing be done more intelligently if the water level is observed closely? Why?

A.—It will by furnishing the fuel to suit the needs of the water supply.

Q.—38. What advantage is it to the fireman to know the grades of the road and the location of the stations?

A.—A great deal, as it allows him to lessen or add to the supply of fuel as may be needed, according to the work the engine has to do.

Q.—39. How should the fire and water be managed in starting from a terminal or other stations?

A.—The fire should be burning bright and of sufficient depth not to tear in holes or to be pulled from the grate. In starting the train the water carried as high as convenient and not cause priming, as this gives the fireman a chance to regulate his fire to the work the engine has to do before it is necessary to add more.

Q.—40. What is the purpose of a safety valve on a locomotive boiler? Why is more than one needed?

A.—To keep the steam pressure at a safe working limit. If one gets out of order the other will act. It is merely an extra precaution against explosion.

Q.—41. What usually is the reason for steam being wasted from the safety valve?

A.—Careless firing and pumping.

Q.—42. What is the estimated waste of coal for each minute the safety valve is open?

A.—About fifteen pounds per minute.

Q.—43. What should be done to prevent waste of steam through the safety valves?

A.—A fireman who is familiar with the road can with good judgment, reduce his fire at shutting off places. Also by the use of the dampers and injector a good deal of the waste can be prevented.

Q.—44. What should be the conditions of fire on arriving at a station where a stop is to be made?

A.—The last fire should have been put in far enough away from the shutting off place to allow all of the gases being burned off of the coal. There should be a good bed of fire in the box so the fire can be quickly rebuilt and steam pressure maintained to start with.

Q.—45. How should you build up the fire when at station in order to prevent black smoke?

A.—By adding fuel often and in small quantities and by cracking the steam valve of blower a little.

Q.—46. What should be the conditions of the fire when passing over the summit of a long grade?

A.—It should be bright and burned rather low, providing you have plenty of water in boiler, thereby doing away with much smoke and keeping engine from popping.

Q.—47. If injector is to be used after passing over summit how should the fire be maintained?

A.—It should be bright and burn freely, and kept that way by adding a little fuel as needed.

Q.—48. Is it advisable to take advantage of every opportunity to store in the boiler as much water as possible?

A.—Yes, but do not pump the engine or carry water

high enough to cause priming or allow it to get into the cylinder.

Q.—49. Why is it that if there is a thin fire with a hole in it, the steam pressure will fall at once?

A.—With a hole in a light fire a great amount of cold air will come through, causing a reduction in temperature of fire box causing it to fall below the igniting temperature of the gases, thereby causing the reduction of steam pressure.

Q.—50. What should be the result of starting a heavy train with too thin a fire on the grates?

A.—The heavy exhausts which accompany the starting of a train will tear a light fire so badly that holes will be formed and a drop in steam pressure will be the result. With a light fire, opening the door a little will prevent the tearing or pulling of the fire a great deal.

Q.—51. How thick a fire should be carried?

A.—This can only be determined by practical experience. The drafting of the engine, the work to be done and the quality of coal all cut a figure. From five to ten inches generally gives good results, the lighter the better.

Q.—52. Where should the coal, as a rule, be placed in the fire box?

A.—In the corner and sides and the bright spots covered, as the center will generally take care of itself with a properly drafted engine.

Q.—53. Is rapid firing advisable?

A.—It is a good plan to get the coal in the fire box quickly and keep the door shut as much as possible, but a good fireman generally takes time enough to fire carefully rather than try to fire too rapidly.

Q.—54. When and for what purpose is the use of rake on fire bed allowable?

A.—To spread the fire, take out clinkers and smooth over banks, but the less it is used the better.

Q.—55. Within what limit may steam pressure be allowed to vary, and why?

A —It is expected that the fireman will keep the engine hot while the engine is at work, but when laying on siding or drifting down long grades it is a good thing to let the steam drop back five or ten pounds so that the engine will not pop away too much water, but much greater reduction in pressure is liable to cause unequal expansion of the sheets, thereby causing flues and stay bolts to leak.

Q.—56. Is it advisable to raise steam pressure rapidly?

A.—Not too rapidly, as it causes unequal expansion.

Q.—57. Has improper firing any tendency to cause tubes to leak? How?

A.—Yes, as improper firing will cause banks and holes and dead spots in the fire, and this means sudden changes in temperature, and that means leaking flues and sheets.

Q.—58. What would you consider abuse of a boiler?

A.—Allowing sudden changes of the temperature in fire box, over pumping, heavy fires, and allowing grates to get stuck.

Q.—59. How would you take care of a boiler with leaky tubes or fire box?

A.—The firing should be done as careful as can be, which will often cause a leaky fire box to take up. Keep out the cold air and the temperature as even as possible. Allow no holes in the fire.

Q.—60. What are the advantages of an arch in the locomotive's fire box?

A.—It maintains an even heat in the fire box. It does not allow the cold air from the door to strike against the flues and aids combustion.

Q.—61. Why is it very important that coal should be broken so that it will not be larger than an ordinary sized apple before being put into the fire box?

A.—It ignites and burns more quickly and completely, and gives better chances for admission of air. If large lumps are used they destroy the air admission

under them and burn slower and often assist the promotion of clinkers.

Q.—62. When and why should you wet the coal in the tender?

A.—There is no real benefit in wetting the coal only to lay the dust, and when very fine or in a slack form then it helps to keep the exhaust from carrying it through the flues or picking up in banks in the fire box.

Q.—63. Should coal be allowed to lay on the deck and fall out the gangway?

A.—Certainly not. A good fireman keeps deck and gangways clean, besides what falls off is so much wasted and costs money.

Q.—64. Do you understand that the coal used on locomotives is property and represents money invested by the company?

A.—I do.

Q.—65. What are the advantages of a large grate surface?

A.—It is claimed that the large grate surface does not need as heavy draft. The consumption of coal is less than with small grate surface and thereby more economical.

Q.—66. Why are the grates made to shake, and when should they be shaken?

A.—The grates are made to shake so that the fire can be kept clean and the ashes be shaken into the pan. They should be shaken often enough to keep from sticking and to keep the fire clean.

Q.—67. Why should grates not be shaken too frequently?

A.—If shaken too often it will not allow a good bed of fire to form and wastes coal by shaking it through into the ash pan.

Q.—68. Is it a fireman's duty to avoid filling up the ash pan too full?

A.—Yes, sir.

Q.—69. Is it permissible to dump ashes or fire over road crossings, switches or around stations?

A.—No, sir.

Q.—70. Is it objectionable to fill the tanks too full or spill water at stand pipe or water tanks?

A.—Yes, sir, it is.

Q.—71. What are the duties of a fireman on arrival at the terminal?

A.—He should care for fire and tools and signal flags and lamps, if any were used, and all other duties laid down by the rules.

Q.—72. Is the engineman responsible for the fireman's conduct while on duty and the manner in which the fireman's duties are performed?

A.—Yes, to a certain extent, in all things pertaining to the engine and its appliance.

SECOND SERIES OF QUESTIONS.

SECOND YEAR.

Question—1. Has there been anything in the past year to interfere with your preparation for this examination?

Answer—Yes or no, as case may be.

Q.—2. Have there been any new signals introduced during the year, or any change of the old ones?

A.—If so explain them.

Q.—3. Have you made any improvement in your method of firing, and have you obtained any better results economically and in smokeless firing during the past year?

A.—There is no reason why the candidate should not truthfully be able to say there has been improvements all around if he has taken the proper interest in his work.

Q.—4. Describe the general form of a locomotive boiler.

A.—There are six principle parts to a boiler: firebox, the shell, the front end flue sheets and flues, and the side and crown sheets, grates and shaker, riggins, ash pan. The fire-box sheets are surrounded by water legs or spaces to prevent burning. At front end of fire-box is

a flue sheet. At back end, the back sheet with door set in; the sheets of the boiler, of which the legs are a part, surrounds the fire box, except at the bottom where the grates are. The outer sheet at the front of fire-box extends to front end in the shape of a cylinder and contains the flues and smoke box at front end, also front flue sheet.

Q.—5. How does the wide fire-box type of boiler with fire-box projecting at each side beyond the wheels differ from the narrow fire-box setting between the wheels, and what advantage has the wide fire-box over the narrow fire-box?

A.—The wide fire-box, the boiler sets over the frame and often projects over the wheels. The narrow fire-box, the boiler sets between the frame. The difference of the two types is in that the size of the fire-box and the heating and grate surface is much greater in the wide fire-box than in the narrow. The advantages, for the wide fire-box are increased heating surface, increased grate area, allowing a larger nozzle to be used, reducing back pressure in the cylinders, using less draft, slower combustion, all three of which lead to economy in the use of fuel.

Q.—6. What is a wagon top boiler?

A. One having the fire-box end larger than the cylindrical part and connected to it by a cone or inclined sheets.

Q.—7. Describe a locomotive fire-box.'

A. It consists of side sheets, flue sheets, crown sheets, back sheets, which the door is fitted into. The side sheet and back sheet and throat sheet, that part below the flues, are supported by stay bolts which extend through to the outer shell. The crown sheet is supported by crown bars or radial stays, which are fastened to the outer shell, also to the back boiler head. The bottom is open, and in it are fitted grates on which the fire is.

Q.—8. Why have two fire doors been placed in some of the wide fire-boxes?

A.—So the firemen can get the coal into the corners with less labor.

Q.—9. To what strain is the locomotive fire-box subjected?

A.—Crushing strain. The strain of the steam pressure, the weight of the water and the strain caused by expansion and contraction.

Q.—10. How are the side and end sheets of the fire-box supported?

A.—By stay bolts screwed into the outside sheets of the boiler and through the fire-box and riveted down.

Q.—11. What purpose is served by the small hole drilled in the outer end of the stay bolts?

A.—As an easy method of finding out when the stay bolts are broken.

Q.—12. In what manner is a crown sheet supported?

A.—There are radial stayed boilers. They are nearly on a line from the center of the boiler. Another form of boiler has a square fire-box and the back end of boiler shell is also square. The direct stays in this boiler are straight. It is known as the Belpaire fire-box. Still another form is by crown bars. These are heavy bars generally set across the fire-box. They have feet at each end bent down and resting upon the seam of the side sheet, keeping the bar above the crown a few inches. The bars are double and a thimble is placed between them and the sheet, and a bolt goes through the sheet, the thimble and the bar, and secured by a nut on the inside. The bars are then attached by stays to the shell of the boiler. These support the sheet.

Q.—13. What is a bad feature about crown bars?

A.—They are hard to keep clean, are heavy and costly and the bars occupy a great deal of the water space.

Q.—14. What are the advantages of radial stayed crown sheets?

A.—It is cheaper and easier kept clean.

Q.—15. How are the inside and outside sheets of the fire-box secured at the bottom?

A.—They are riveted on the outside and inside of a

heavy ring the shape of the fire-box, known as the foundation ring, or more commonly called the mud ring.

Q.—16. Describe the ash pan and its use.

A.—The ash pan is a receptacle below the bottom of the fire-box to catch and hold ashes and fire, and is fastened to the mud ring usually. It is provided with a door at each end that are called dampers, and are used to regulate the amount of air admitted to the fire and for the removal of the ashes.

Q.—17. Why are boilers provided with steam domes?

A.—They give an extra receptacle for dry steam and a convenient place to put the throttle valve, safety valve and other fittings.

Q.—18. What must be the condition of a boiler to give the best results?

A.—It must be clean, its heating surfaces clear of scales and other foreign matter, and the circulation of the water must be good.

Q.—19. What is meant by circulation in a boiler?

A.—The movement of the water in the boiler in such a way as to come in contact with the heated sheets. A fresh supply of water taking the place of that evaporated.

Q.—20. What would be the result if the leg of the fire box became filled with mud?

A.—The sheets would become overheated and be mud burnt.

Q.—21. What would be the result if a fire box sheet became overheated?

A.—If it became hot enough and there was pressure enough on it, it would be forced off the stays and an explosion might occur. Also liable to crack when cooling.

Q.—22. Why are boiler checks placed so far away from the fire box?

A.—So as to introduce the feed water as far from the fire as possible, and allow it to become more or less heated before it comes in contact with the hot sheets of the fire box.

Q.—23. What part of the locomotive boiler has the greatest pressure?

A.—The bottom of the boiler, as it has the steam pressure and the weight of the water both to sustain.

Q.—24. What should the length of a locomotive smoke box be?

A.—Long enough to supply room for the steam pipes, exhaust nozzles and draft appliances.

Q.—25. What object is there in having the exhaust steam go through the stack?

A.—In order to produce a vacuum in the front end which in turn will allow the air to pass into the fire box through the ash pan and grates, thereby promoting combustion and assisting the gases and smoke through the flues in to the front end and out of the stack.

Q.—26. How does this effect the fire?

A.—The air forces itself up through the ash pan grates and fire to supply the vacuum in the front end, thereby producing an artificial draft on the fire.

Q.—27. What should be done to prevent black smoke from trailing when the throttle is closed?

A.—Open the blower a little.

Q.—28. What are the adjustable parts in the front end by which the fire is regulated?

A.—The petticoat pipe and sleeve and the deflector plate and its extension and the exhaust nozzle tip.

Q.—29. Explain what adjustments can be made and the effect of each adjustment on the fire.

A.—The petticoat pipe and sleeve are simply an uptake pipe standing between the nozzle and the base of the stack. By raising and lowering, a change is made in the amount of draft and effects the even burning of the fire. When the deflector plate is high, if the distance between the bottom of the petticoat and the top of the nozzle is large compared with the opening between the top of the petticoat and the bottom of the stack, the draft will be greater through the bottom flue, causing the fire to burn faster at the front of the fire-box, and vice versa. The deflector plate is the usual means of regulating the draft

to cause the engine to burn an even fire. Lower it to cause the draft heavy or to have the fire burn the most at the flue end of the fire-box and raise for the back end. The exhaust nozzle tip can be changed to increase or to reduce the size of the nozzle. The larger the less draft, the smaller the more draft. It also effects the back pressure in the cylinder.

Q.—30. What is out of place when the exhaust steam and smoke issue from one side of the stack?

A.—When the steam and smoke issue from the side of the stack it denotes that the nozzle is out of line with the stack, or the petticoat pipe is out of line with the exhaust stand and stack. This should be remedied as soon as possible, as it interferes with the proper action of the exhaust.

Q.—31. What effect has the stoppage of a large number of flues?

A.—It would effect the even burning of the fire. Also reduces the heating surface of the boiler, as a large part of the heating surface is in the flues.

Q.—32. What is the effect of leaky steam pipe joints inside of smoke box?

A.—The steam that leaks by the joints expands in the smoke box and destroys the draft thereby effecting the steaming qualities of the engine.

Q.—33. What causes pull at the fire door?

A.—Is it caused by the rush of air towards the front end to supply the vacuum there, also the exhaust.

Q.—34. Give briefly your opinion as to the best method of firing locomotives.

A.—Carry a light level fire. Fire light and often; have the coal well broken up and keep the corners and sides well up and the white spots covered. There are hardly any two engines that fire alike. As a whole it is a question of good judgment gotten only by a close attention to work and practical experience. Supply the fuel when needed and keep the door open as little as possible. Burn the fire down a little when approaching

places where the engine is shut off. Crack the blower a little if necessary to avoid black smoke.

Q.—35. If upon opening the fire-box door you discover what is commonly called "red fire," what might be the cause?

A.—A dirty fire. Clinkers or too heavy a fire, for the dull red fire indicates that the fire is not getting enough air.

Q.—36. What conditions will permit of holes being torn in the fire?

A.—Too small a nozzle, dirty fire, clinkers in places improperly drafted, or else the fire has been banked in places and is too thin in others.

Q.—37. Is it a waste of fuel to open the fire-box door to prevent pops from opening? How can the necessity for this be prevented?

A.—Yes, it is a waste of fuel. The best remedy is to fire carefully and keep up the pressure, but avoid the necessity of cooling to prevent popping often.

Q.—38. What is the cause of the drumming noise when the engine is shut off? How can it be avoided? Why should it be avoided?

A.—The drumming is caused by an explosion of the mixing of the gases and air, and can be avoided by opening or shutting the door as may be. Also by dropping the dampers or adding a little fresh fuel so as to change the condition of the fire-box so as to do away with the explosive elements. It should be stopped, as it is very unpleasant to hear.

Q.—39. What is an injector?

A.—An injector is a mechanical device for forcing water into a boiler.

Q.—40. In a general way what are the two kinds of injectors?

A.—The lifting and non-lifting injectors.

Q.—41. What is the difference between a lifting and a non-lifting injector?

A.—A lifting injector will lift the water from the tank and can be placed above the water line in the tank.

The non-lifting must be below the lowest water level of the tank.

Q.—42. What are the essential parts of an injector?

A.—An injector has four connections outside, namely: the steam supply pipe, the waste supply pipe, the overflow pipe and the delivery pipe to the boiler. The inside parts are the lifting steam nozzle, the lifting tube, forcing steam nozzle, the combining and condensing tube and the delivery tube. There are also the line check valve and the water valve.

Q.—43. How should an injector be started?

A.—Open overflow and water valves. See that water passes freely. Open steam valve gradually until water ceases to flow through overflow, but passes through check into boiler.

Q.—44. Give some of the common causes for failures of injector to work.

A.—Leakage of air in the suction pipe, kink in hose, strainer stopped up, failure to lift water, water too hot, leaky boiler, check tubes out of line, with others too numerous to mention.

Q.—45. What course should be pursued with a check valve stuck open?

A.—Tap the check valve casing with a soft hammer. If this fails pour two or three buckets of cold water on valve, this may cause it to seat. Close overflow to prevent water from wasting or blowing back into the tank.

Q.—46. How may it be determined whether the check valve or steam valve is leaking?

A.—Close main steam valve, and if it stops it is the steam valve, but if it does not stop it is most likely the check valve.

Q.—47. What may be done in this case?

A.—When injector is shut off, close water valve to prevent heating of the water. If water is hot blow back in tank by closing overflow valve and opening steam valve. Then close the steam valve and open overflow, and the cold water coming from the tank into the injector will generally allow the injector to prime.

Q.—48. What may be done if a combining tube is obstructed?

A.—The injector must be taken apart and obstruction removed.

Q.—49. How may it be determined if the trouble is on account of a leak in the suction pipe?

A.—Test by steam. Close tank valve and overflow valve and turn a little steam into suction pipe and leak will show.

Q.—50. What should be done in case of obstructed hose or strainer?

A.—Close overflow valve and blow back steam into tank; if this will not clean it, it must be taken down and cleaned.

Q.—51. What should be done in case the feed water in tank is too hot?

A.—Would throttle down main steam valve. If this failed, would run to nearest tank, as the water must be cooled in some way, as the injector will not work if it is too hot.

Q.—52. Will an injector work if all of the steam is not condensed by water?

A.—No, sir.

Q.—53. If it is necessary to take down the tank hose how can the water be prevented from flowing out of the tank that has the siphon connection instead of the old style tank valve?

A.—Open the pet cock at top of siphon.

Q.—54. Explain how water in the delivery pipe can be protected from freezing.

A.—There should be a drain cock at lowest point in pipe, usually underneath the check valve. Keep it open when not working injector.

Q.—55. Explain how you would prevent the waste pipe freezing, either while the injector is working or shut off.

A.—Use the heater, or unseat the overflow valve and let small currents of live steam pass through, or when working it may be necessary at times to cut down water

supply so that a little hot water will pass through the waste pipe.

Q.—56. How can the suction pipe and injector hose be protected from freezing?

A.—Use the heater.

Q.—57. Explain how the heater is used on a lever monitor injector?

A.—Close overflow valve and the steam throttle low at the main valve. The steam valve should then be opened and enough steam allowed to pass back to answer as a heater.

Q.—58. How is the heater used with the screw monitor injector?

A.—Same as above.

Q.—59. Is the indication of water level by the gauge glass a safe indication if the water level is not moving up and down when the locomotive is in motion?

A.—No, if the glass is working right it will move up and down when the engine is in motion.

Q.—60. Is any more water used when an engine foams than when water is solid?

A.—Yes. Some passes into the cylinder with the steam.

Q.—61. Describe the manner in which a sight feed lubricator operates.

A.—Part of the steam in the condensing chamber is condensed. The water valve allows this condensed steam to flow down to the bottom of the oil reservoir. Oil being lighter than water, the oil comes to the top of the water. The oil pipe at the bottom of the sight feed arms extend to the top of the oil reservoir and the oil passes down through them to the regulating valve from the condensing chamber. The equalizing tubes lead into the top of the sight feed arm, so that the pressure on the top of the water in the glass is equal to the pressure acting on the oil at the bottom of the glass, and the weight of water in the condensing chamber is sufficient to cause the difference in pressure that causes the oil to flow drop by drop through the regulating valve, then

passes through the water in the feed glass and is carried by the current of steam through the flues into the oil pipe, thence by gravity to the steam chest and cylinders.

Q.—62. How should a lubricator be shut off before filling?

A.—Shut off regulating valves, water valve, then steam valve. Open the drain plug, then filling plug, and after the water has drained out, close drain plug and fill through filling plug.

Q.—63. Will any bad results ensue from filling the lubricator full with cold oil?

A.—Yes, as oil heats it expands and might burst the lubricator. There are many makes of lubricators that now have air chambers for this purpose.

Q.—64. Which is the better practice, to close the feed valves or water valves, while waiting on sidings, etc.?

A.—The feed valves.

Q.—65. In what order should valves on lubricators be opened?

A.—First the steam valve, giving a little time for condensation, allowing chamber to fill with water; then the water valve, then the feed valves.

Q.—66. Does the draft from the open cab window affect the working of the lubricator? Why?

A.—Yes; in some cases, where the equalizing tubes are outside the condensing chamber. The cold air striking these tubes condenses part of the steam passing through them, thereby reducing the pressure on top of the water in the feed glass, causing the lubricator to feed faster.

Q.—67. What else might cause irregularity of the feed?

A.—Worn or stopped up choke plugs will cause irregular feeding.

Q.—68. If the lubricator feeds faster when the throttle is closed than open, where is the trouble?

A.—Choke plugs too large or steam valve not open

full, thereby not getting full boiler pressure on top of water in feed glasses.

Q.—69. If the sight feeds get stopped up, how should they be cleaned?

A.—Should be blown out. Close the other feeds and water valves and have steam valve open. Also open drain plug a short time. This will cause the steam to pass through the feed that is stopped up; if not, the lubricator will have to be taken apart or go to the shop.

Q.—70. How should the choke plugs be cleaned?

A.—Close regulating valves and steam valves, open drain. With the throttle wide open and these valves shut, the pressure will blow back into the lubricator through the choke plugs, if not they must be taken out and cleaned by hand.

Q.—71. Can you explain the use of the equalizing pipe?

A.—It furnishes a passage for the steam pressure above the water in the feed glasses. It also allows steam to pass through the choke plugs and through oil pipe assisting oil on its course to steam chest and cylinder.

Q.—72. What will be the effect if an equalizing pipe were broken off or became very loose?

A.—It would stop the feed, but if plugged where it enters the condensing chamber and at the end that enters the feed arm, the other feeds could be used.

Q.—73. How can it be known whether the equalizing tubes are stopped up?

A.—If stopped up, the oil would run in a stream through the glass when regulating valve was opened.

Q.—74. Can you explain why when engine is being worked slowly with full throttle, the valves become dry and the lever jumps when the lubricator is apparently feeding all right?

A.—Too much back pressure in oil pipe. When the throttle is open wide it gives nearly boiler pressure in the steam chest, hence the oil can not get to the valves, causing them to become dry.

Q.—75. What would you do under these circumstances?

A.—Close the throttle for a moment, allowing the oil to pass to valves.

Q.—76. How many drops in a pint of valve oil fed through a lubricator?

A.—Between 5,000 and 6,000 drops. Depends on size of drop used.

Q.—77. Assuming that five drops per minute are fed to each of the valves and a drop per minute to the pump how many hours would be required to feed a pint of valve oil?

A.—The three feeds use eleven drops per minute and eleven will go in 5,500 just 500 times, and 500 minutes will make just eight hours and twenty minutes, assuming that each pint contains 5,500 drops of oil.

Q.—78. Assuming that the engine is running twenty miles per hour how many miles per pint would be run?

A.—Multiply the hours by twenty and it gives you the answer.

Q.—79. How many drops per minute should ordinarily be used?

A.—Five for each valve and one for air pump?

THIRD SERIES OF QUESTIONS.

FINAL EXAMINATION.

Q.—1. What are the duties of an engineman before attaching the locomotive to the train?

A.—Examine work book and see if work reported was done. Also the bulletin board for new orders. Try gauge cocks to see if water level in boiler and water glass correspond. Examine fire box and flues for leaks. See that the proper supply of water and sand and fuel is on the engine and tender. Also if the necessary signal appliances and tools are in their proper place. Start air pump and note air pressures are standard. Oil the engine and give a careful inspection at same time and be ready to leave when called for.

Q.—2. What tools should be on the locomotive?

A.—Name the tools allowed by the company for which you are working.

Q.—3. What examination should be made after any work or repairs have been done on valves, brasses, etc.?

A.—See that work had been done and that oil holes had not been stopped up and the parts that had been worked on should be well watched while on the road to keep from heating or cutting.

Q.—4. How can it be known whether a boiler is carrying the proper steam pressure?

A.—Note the pressure shown by the gauge while popping and see if it is the same the engine is rated to carry.

Q.—5. What attention should be given to boiler attachment such as gauge cock, water glasses, etc.?

A.—They should be inspected and blown out often enough to be certain that they are working properly.

Q.—6. Is smokeless firing practicable?

A.—Yes, with fuel and service favorable.

Q.—7. Trace the steam from the boiler through the cylinder to the atmosphere and explain how it transmits power.

A.—Steam passes from the dome through the throttle valve and dry pipe and steam pipe into steam chest, through the ports into cylinder, through the exhaust cavity and passage into saddle to exhaust stand in front end, through nozzle out to stack. It gets its power by expanding in the cylinder against the piston head, causing it to move the engine by connections with the cross head main rod and crank pin on the driving wheel.

Q.—8. How much power have the piston and cross head on one side to turn the crank pin when the center of the wrist pin, the crank pin and the main driving axle on the same side are in a straight line?

A.—No power as the engine on that side is on the dead center and there is no leverage to cause the wheel to turn.

Q.—9. How then is the engine kept going?

A.—Because the engine on the other side is on her power or at right angle and is receiving the full power on that side.

Q.—10. What is meant by working steam expansively?

A.—Cutting off the admission to the cylinder when part of the stroke is completed and permitting the steam admitted to do work by expanding itself.

Q.—11. How should the locomotive be started to avoid jerks and what train signals should be looked for immediately after starting?

A.—Slowly till all slack is out of the train then full power can be used; look for all-right signal from rear of the train.

Q.—12. After a locomotive has been started, how can it be run most economically?

A.—With throttle open as far as engine will stand and lever hooked back as near the center of quadrant as can be done while retaining the required speed, thereby using the steam expansively.

Q.—13. If you discovered that a fixed signal was missing or was imperfectly displayed, what should you do?

A.—Stop and be governed the same as if it was a danger signal.

Q.—14. How rapidly should the water be supplied to the boiler?

A.—As evenly as possible, according to the work the engine has to do and how she steams.

Q.—15. What is the difference between priming and foaming of a locomotive boiler?

A.—Priming is generally caused by the boiler being over pumped. Foaming is caused by alkali, oil, grease, mud or other impurities in the water or boiler.

Q.—16. What should you do in case of foaming in the boiler?

A.—Would shut off throttle to find true water level. Put on injector and open blow-off or surface blow, if I

had one, to work off bad water, and handle engine carefully so as to not burn boiler or knock out cylinder heads.

Q.—17. What work about a locomotive should be done by the engineer?

A.—The work varies on different roads. A good man will generally know if his wedges are properly set up, rod brasses lined up, oil holes open, that tank hose and strainer are cleaned out and that injector and air brakes are all O. K.

Q.—18. What danger is there when the water foams badly?

A.—Danger of burning the boiler, as the true water level is hard to find.

Q.—19. How should the work of setting up the wedges be done?

A.—Have them so neatly adjusted there will be no thumping of the boxes and at the same time not so tight as to cramp and not allow them full and free play on the pedestals.

Q.—20. How should rod brasses be keyed?

A.—When keying have brasses press against the largest part of the pin and key just tight enough so they can be moved laterally by hand.

Q.—21. How should an engine be placed for the purpose of keying rod brasses?

A.—Should be placed on straight level track. Have wedges set up and put engine on dead center (for side rods). Slack off all keys on that line of rods. Would then key the main connections, first leaving it free enough on the pin so it could be moved laterally by hand. Then adjust the front and back end in the same manner for main rod. Would put the engine on the bottom quarter for forward end, as in this position the brasses will press against the largest part of the pin (the back end). Would put the engine on the forward top eight, as in that position we find the brasses against the largest part of the pin.

Q.—22. What is the necessity of keeping brasses keyed up properly?

A.—To keep the rods from pounding. Badly pounding rods affect the whole machinery of the engine.

Q.—23. How should the side rods on a mogul and consolidation locomotive be keyed?

A.—First part of the answer to question No. 21.

Q.—24. What is meant by engine out of tram?

A.—An engine is out of tram when the wheels on one side lead the wheels on the other side, or when the distance between any two wheel centers are not the same as the centers on the corresponding wheels on the other side.

Q.—25. Why is it important that there be no holes through smoke box sheets or front end, or in the smoke box seams or joints?

A.—It causes the front end to burn and warps the iron, also is hard on the steaming qualities of the engine where the front end gets air.

Q.—26. Describe a piston valve.

A.—A piston valve consists of two pistons connected together by a stem. The whole resembles a spool in shape. This fits into a cylinder known as the valve chamber. The steam ports are in this chamber. The heads of the valves are provided with packing rings. The edges of these rings form the edges of the valve. Steam is admitted between the heads if it is an inside admission valve, and outside, if it is an outside admission valve. To the chamber the action of the valve is very similar to the slide valve except that this valve is round instead of flat, and being rounded the pressure equal all around makes an almost perfect balance valve of it.

Q.—27. What is a balance slide valve? How is it balanced, and why? For what reason is the hole drilled through the top of the valve?

A.—A balance slide valve has rings or balance strips placed on the top of the valve itself, which make a bearing against a balance plate which is on the underside of the steam chest cover. These strips are held in place in such a manner that they form a steam-tight joint

against this balance plate in all positions of the valve, and thus the boiler pressure is prevented from acting on a large part of the surface of the valve, thereby reducing the pressure between the valve and the seat, thus reducing the friction of the valve on its seat greatly. The hole is drilled through the valve from the space enclosed in the balance strip to the exhaust cavity to allow steam that leaks by the strips to escape to the exhaust.

Q.—28. What is meant by inside and outside admission valves?

A.—Where steam is admitted to the ports around the outside edges of the valve, it is an outside admission valve, and if admitted around the inside, it is an inside admission valve. Piston valves are the only inside admission valves in use.

Q.—29. What is the relative motion of main piston and valve, for inside admission valve, and for outside admission valve?

A.—For outside admission the valve moves in the same direction as the piston when steam is admitted and right opposite to the piston for inside admission.

Q.—30. What is the difference in the valve motion for outside admission valves and inside admission valves?

A.—The motions are exactly opposite to each other. For instance, if you want to change from outside admission valve with an indirect valve gear to an inside admission, the valve motion must be changed from indirect to direct to get good results.

Q.—31. What is a direct motion valve gear? What is an indirect motion valve gear?

A.—A direct motion valve gear is one in which the valve stem moves in the same direction as the link block. An indirect motion is one in which the valve stem moves opposite to that of the link block, due to the fact that the link block motion is transmitted to the valve stem through a rocker arm.

Q.—32. What is meant by lead?

A.—The amount of port openings made by the valve when the piston is at the beginning of the stroke.

Q.—33. What is meant by steam side lap?

A.—Steam side lap is the amount that the steam edge of the valve overlaps the steam ports when the valve is on its center.

Q.—34. What is meant by exhaust side lap and by exhaust side clearance?

A.—Exhaust side lap is the amount that the exhaust edge of the valve covers the steam port when the valve is on the middle of its seat. Exhaust side clearance is the distance which the inside edge of the valve comes short of covering the steam port when the valve is on the middle of its seat.

Q.—35. What would be the position of the eccentric relative to the crank pin? With direct motion valve gear? Why?

A.—With an indirect valve motion and outside admission valve the go-ahead eccentric follows the pin and the back-up eccentric leads the pin, but with an inside admission valve the relative positions are exactly opposite.

The reason why is that the angle that the eccentric makes with the pin is a little less than ninety degrees according to the lead and lap of the valve.

Q.—36. What effect would be produced upon the lap and lead by changing the length of the eccentric rods?

A.—None whatever on lap, as lap is always measured when the valve is on the middle of the seat, lead being measured for when the engine is on its dead center. therefore, changing the length of the eccentric rod would change the lead accordingly.

Q.—37. Why are eccentric rods made adjustable?

A.—It provides an easy means of squaring the engine up.

Q.—38. Why is it necessary to keep the cylinders free from water?

A.—Water washes off the oil and makes greater chances of cutting the valves and cylinders. It also occupies space better occupied by steam, and with water in

cylinder you are liable to knock out a head or burst a cylinder.

Q.—39. Where is piston rod packing located? Cylinder packing?

A.—Piston packing is in a stuffing box or gland fastened by studs to back cylinder head. It surrounds the piston and forms a steam-tight joint. Cylinder packing is generally rings sprung around the piston head to form a steam-tight joint by expanding against the wall of the cylinder.

Q.—40. How are the metallic packing rings on valve stems and piston rods usually held in place, and what provision is made for the uneven movement of the rods?

A.—By springs, usually, which crowds the packing against the rod and forms a steam-tight joint. Provision is made for the uneven movement of the rod by means of what is known as a vibrating cup, which is a brass ring which, with the rest of the packing, forms a kind of ball joint against the gland and allows the uneven movement of the rod without affecting the fit of the packing rings much.

Q.—41. What is the cause of tank sweating, and what will prevent it?

A.—It is caused by the water being colder than the atmosphere, thereby gathering moisture from the surrounding atmosphere. To prevent, heat the water in the tank.

Q.—42. What is friction?

A.—The force which seems to resist the sliding of one body on another is called friction.

Q.—43. Upon what does the amount of friction depend.

A.—The amount of friction depends on the weight and roughness and kind of materials brought together.

Q.—44. What is the effect of the introduction of oil or other lubricants between frictional parts?

A.—The introduction of lubricants change the friction from that of one solid against another to that of

fluid friction, causing a film of oil to be between them and allow much freer movement of the parts.

Q.—45. Explain the principles on which grease cups operate. What is the objection to using water on a hot pin when grease is used on a hot pin with babbitted brasses?

A.—A grease cup is merely a cup with a threaded plug to screw in the top, and when filled with grease, the plug being screwed down forces the grease out the oil holes. The more pressure on the plug, the more grease. Water has a tendency to wash off the grease, but can be used often with good results, but with babbitted brasses should not be used until all the babbitt is thrown out, as it might stop up the oil hole.

Q.—46. Explain the construction and operation of the blow off cock.

A.—There are several kinds of blow-off cocks in use, the commonest one consists of a two-way cock and must be operated by hand. There are also blow-offs that are operated by steam and air.

Q.—47. Describe a bell ringer and how it may be adjusted?

A.—A bell ringer consists of a cylinder with a piston into which a rod extends which is connected to the bell crank. When pressure is put on the ringer it raises the piston a certain distance, thus forcing up the rod and turning the bell. When the piston has moved up a certain distance the admission of pressure is stopped by the movement of a valve connected to the piston and the exhaust ports are opened. The return of the bell forces this piston down, again moving the valve. Uncovering the admission ports, closing the exhaust ports and the piston again make an up stroke. This being repeated keeps the bell ringing.

Q.—48. How should the blower be used when an engine is on the cinder pit?

A.—It should be used as little as possible, as it draws in cold air and has a tendency to cause boiler and flues to start to leaking.

Q.—49. In case the locomotive in your care became disabled on the road, what should you do?

A.—Would protect my train according to rules and notify the proper officials and get the engine ready to be towed in as far as possible with means at hand.

Q.—50. Suppose a wash-out plug blew out, or a blow-off cock broke off and would not close, what should be done?

A.—Start injector and smother or put out the fire the quickest way. Then either prepare to be towed in or fit a plug in hole and fill boiler and come in under steam if time and conditions permitted.

Q.—51. What should be done should the grate be burned out or broken while on the road?

A.—If only partially burned out or only one section broken would get fish plates or bricks or stones or, if I could would use small pieces of T rails or anything to keep fire out of ash pan and hole stopped up, but if all gone would dump fire and ask for help.

Q.—52. What precaution should be taken to prevent locomotives throwing fire?

A.—Examine the netting often for holes and have fixed before starting.

Q.—53. What should be done with a badly leaking or bursted tube?

A.—Plug it if possible with iron plugs, if had them, if not, a green, young tree or sapling can be used. Drive in flue and let burn off. It will not burn only flush with the sheet. Plug the fire box end first, if a bursted flue, then the front end.

Q.—54. Suppose that immediately after colsing the throttle the water disappeared from the water gauge glass, what should be done?

A.—Would re-open throttle, hooking the lever in center if necessary to stop and get injector to work at once to increase supply.

Q.—55. What should be done in case a throttle stem becomes disconnected while the throttle valve is closed? While throttle valve is open?

A.—If inside the dome and became disconnected shut off, would notify the proper authorities and get ready to be towed in. If disconnected open, by reducing pressure and with good brakes would try and bring engine in, but would be very cautious. If outside the dome, where disconnected, it might be repaired with small delay.

Q.—56. In the event of a slide valve yoke or stem becoming broken inside of the steam chest, how can the breakage be located?

A.—Place the engine on a quarter, open the cylinder cocks, admit steam to the steam chest, then reverse the engine two or three times, and if steam did not flow alternately from each cock, the yoke on that side is broken.

Q.—57. After locating a breakage of this kind how should one proceed to put the engine in safe running order?

A.—Cover the ports with the valve and fasten it in that position. Disconnect the valve stem and main rod, come in with one side working, or you can leave up main rod if your cylinder has indicator plugs, or you can devise some means of getting oil in the cylinder (or look for other methods in the break-downs in this book.)

Q.—58. If a slide valve is broken what can be done to run the engine with one side?

A.—The only thing that can be done if the valve is badly broken is to plug the steam admission ports to the steam chest or the steam admission ports to the cylinder, or some times there are cases when a thin board can be slipped between the valve and its seat and block the valve down on this board. If this can not be done the admission ports must be blocked and steam chest bolted down to hold the blocking. Disconnect valve rod and provide some proper means to oil the cylinder or take down main rod.

Q.—59. What should be done in case of link saddle pin breaking?

A.—Put reverse lever in quadrant where engine will handle train and fit block between the top of the link block and the top of the link so the valve on broken side will

have sufficient cut off to handle train. Always remember the engine can not be reversed without first changing the blocking and using a longer block on bottom of link.

Q.—60. With one link blocked up, what must be guarded against?

A.—Against reversing. If reversed, one side will be going ahead and one side back, and sure to cause breakage somewhere.

Q.—61. How can it be known if the eccentric has slipped on the axle?

A.—The engine will go suddenly lame. To tell which eccentric has slipped place the lever in extreme forward notch, move the engine slowly with clyinder cocks open. If steam escapes from both cocks at the same time the cross head reverses its motion, the go-ahead eccentric is all O. K., but only from one it indicates it is slipped, and if the engine sounds all right in full gear and is lame when hooked up, it indicates the back up eccentric has slipped.

Q.—62. Having determined which eccentric has slipped, how should it be re-set?

A.—There are several ways to set an eccentric, but about the quickest and easiest way is to put the engine on dead center on slipped side and move the eccentric till steam shows at the cylinder cock. It will be near enough right to get in with.

Q.—63. What should be done in case of broken eccentric strap or rod?

A.—Remove all broken parts, take down other rod and strap, disconnect valve stem and clamp valve on middle of seat and go in with one side working, but if a forward motion rod or strap breaks only a short distance from terminal you can get her in without taking down the back motion rod or strap. Remove the broken parts, disconnect valve stem, clamp valve in middle of seat, take off link hanger and let the link ride on the link block, oil cylinder through indicator plugs in cylinder.

Q.—64.—How should the engine be disconnected if a lower rocker arm becomes broken, if a link pin?

A.—Remove broken parts and disconnect; put valve on middle of seat. **Make sure link will clear everything and proceed with one side working.**

Q.—65. What would be considered a bad tender or engine truck wheel?

A.—One that the flange is broken on or is cracked, that has bad flat spots on or with a very sharp flange.

Q.—66. What should be done if an engine truck wheel or axle breaks?

A.—If forward wheel or axle it is best to send for help and a new pair of wheels, but if back axle or wheel chain up back end of truck frame to engine frame. First jack up front end of engine to take weight off truck, raise axle and put block under to hold it up. Then jack up the journal box and truck frame and chain to frame so as to hold it up. Chain the other side of truck to engine frame so as to prevent good wheel from dropping off the rail. Then block between engine frame and front end of equalizer on broken side to relieve broken wheel of weight. If only a short distance to siding the wheels can be skidded or slide to get into clear main line.

Q.—67. What should be done if a tender wheel or axle breaks?

A.—If wheel breaks skid it in. Fasten a piece of oily waste so it will oil the rail and let it run as easily as possible. If broken axle, probably the easiest way out of it would be to send for help and a pair of wheels to put in, but it has been done by putting a cross-tie across the top of tank and chain truck to it in such a manner as to carry the weight on broken part.

Q.—68. How should an engine be blocked for broken engine truck, spring or equalizer? For broken tender truck spring?

A.—For broken truck spring block between the top of the equalizer and the truck frame. thereby holding truck in place and distribute the weight on the boxes. If equalizer breaks the weight must be taken off of the boxes so that you can block between the top of the boxes and the truck frame. and hold the truck in its usual posi-

tion. Broken tender truck spring, would block solid from tank sills to truck frame and run careful.

Q.—69. If it is not necessary to take down the main rod on disabled side of engine how would one arrange to lubricate the cylinders?

A.—They may be oiled through the indicator plug holes if those are provided, or the cylinder cocks may be removed, or cylinder head taken off, or in some cases through the relief valves, or the valve may be clamped so as to leave a little opening to the back end of the cylinder and oiled by the lubricator, but if this is done the back cylinder cock must come out.

Q.—70. What should be done if a driving spring, spring hanger or equalizer should break?

A.—What to do depends on the class of engine and the way the springs and equalizers are put up, but the weight must be taken off the driving boxes, so run the engine upon a wedge of hard wood and put blocks between boxes and frame, then run the other wheels up so as to block between the ends of the equalizers and the frame so as to distribute the weight as near equal on each box as possible.

Q.—71. How can an engine be moved if the reverse lever or reach rod where caught at short cut-off by a broken spring or hanger?

A.—Take out pin at end of reach rod where it connects to lifting shaft arm, then pry the links into the positions wished and block them there if necessary.

Q.—72. How can a blowing of steam past a valve, cylinder or packing or valve strip be distinguished and located?

A.—A cylinder packing blow will be greater at the beginning of the stroke and decrease towards the end as the steam pressure in the cylinder decreases. A valve strip blow will be continuous while using steam and has a whistling sound. A valve blow depends altogether on whether the valve is cut or broken, or how bad. It may only blow in one position or at one certain point. Experience is the best in this case.

Q.—73. If a simple engine should blow badly and be unable to start the train when on the right hand dead center, on which side would be the blow generally?

A.—On the left side.

Q.—74. If the throttle was closed and steam came out of the cylinder cocks, what might be the cause?

A.—A leaky dry pipe or a leaky throttle. Either would cause this.

Q.—75. Is it possible to distinguish between a leaky throttle and a leaky dry pipe?

A.—Yes. A leaky throttle will only allow dry steam to be shown at the cylinder cocks, while with a leaky dry pipe a great deal of water will be carried with the steam to the cylinder cocks.

Q.—76. What effect have leaky steam pipes, and how should they be tested?

A.—They affect the steaming of the engine very much. To test leaky steam pipes open the front end and give the engine a little steam and examine the joints for leaks, but the proper test should be made at the round house with water pressure.

Q.—77. How should the test for a leaky exhaust pipe joint, or a leaky nozzle joint be made?

A.—Plug the exhaust tip, open the throttle and move the reverse lever from back to forward motion several times is a very good test, but a better one is with water pressure, or sometimes the leak can be located by opening the front end while the engine is working slowly, and the absence of cinders or sparks around the joint of the nozzle will indicate the leak.

Q.—78. How should hot bearings be treated?

A.—See that oil holes are open and be sure that bearing gets plenty of oil, or valve oil soap or graphite are all good, or a mixture of all of them is better. In some cases water can be used with good results.

Q.—79. What should be done if steam chest cracks?

A.—It can usually be tightened enough to get in by driving wedges between the studs and the walls of the

chest. Of course the casing will have to come off to do this.

Q.—80. What should be done if steam chest breaks?

A.—About the only thing to be done is to block the steam admission ports to steam chest. Use a fish plate to hold blocking if the chest cover is broken so it can not be used by fastening to the studs.

Q.—81. If a link lifter or arm were broken, what should be done?

A.—Put a block between the top of the link block and the top of the link long enough to allow the engine enough cut-off to handle the train. If you reverse the engine the blocking must be reversed, using a longer block. Never try to reverse engine while block is in link.

Q.—82. If the reverse lever or reach rod should break what should be done?

A.—Same remedy as for broken link lifter.

Q.—83. What should be done if the piston, cross head, connecting rod, or crank pin is bent or broken?

A.—With broken or bent piston take off all broken parts. Clamp valve in central position and leave up the main rod if nothing is broken to hinder. If cross head. crank pin, or rod were bent or broken, would remove all broken parts and clamp valve in middle of seat and block cross head and go in with one side working.

Q.—84. What should be done if safety valve spring breaks?

A.—When pressure was reduced would screw out valve and fit a wood plug so it would hold when valve was screwed in again and go on using other prop to relieve boiler of any excess pressure.

Q.—85. How can an engine be brought in with broken front end or stack?

A.—Use an old barrel for a stack. Use bell cord or wire to fasten it on. Would board up front end. Grain doors, or car doors are handy for this, and come in with light engine, as she would not make steam enough to handle train in most cases.

Q.—86. What should be done when a frame is broken between the main driver and cylinder?

A.—Set out train and disconnect the valve stem, clamp valve centrally and come in with light engine on one side, unless your rules say different.

Q.—87.—What should be done when there is a loose or lost cylinder key?

A.—Would replace it with a wedge of some kind, if nothing at hand would get one at nearest blacksmith shop, as running without it might cause serious damages.

Q.—88—What should be done if frame should break back of main driver?

A.—Would set out train and run in light, as the light engine can be handled without danger of damage.

Q.—89. In case of broken side rods, what should be done?

A.—Remove all broken parts and always take off the corresponding rods on the other side.

Q.—90. What can be done if the intermediate side rods were broken on a consolidation engine having the eccentric on the axle ahead of main wheels?

A.—Would get ready to be towed in, as leaving up the opposite rods is not safe, for should the engine slip it might do much damage.

Q.—91. Should one of the forward tires of a ten wheel engine break, what must be done to bring the engine in?

A.—Remove the broken parts, run the wheel upon a wedge, remove the cellar and block between the axle and the pedestal brace high enough to hold wheel clear of rail, put some oily waste on block for lubricant for block. Then block between the spring saddle and the top of the frame. This will take the weight off from the top and the wheel will clear the rail and the weight of the journal will be on block in place of oil cellar; would also cut out driving brake.

Q.—92. What is a good method of raising a wheel when jacks are not available?

A.—A wooden wedge of hard wood, if possible to get.

Q.—93. How can it be known whether the wedges are set up too tight and the driving box sticks, and in what manner can they be pulled down?

A.—If stuck, the box will generally run hot and the engine ride very hard. Would run engine over a block and try to jar it down if it could not be pulled down by the nut and screw provided for adjusting them, or might get it down by prying or sledging it.

Q.—94. In reporting work on any wheel or truck on engine or tender, how should they be designated?

A.—On most roads the wheels go by number, starting with the lead driver on the right side as No. 1 driver, and so on back to No. 3 or 4, as the case may be. Starting with No. 1 in the lead on the left side same way, with engine trucks or tender forward or lead wheel always being No. 1, always stating which side, either right or left.

Q.—95. What are some of the various causes for pounds?

A.—Brasses improperly keyed or loose wedges, broken frames, loose cylinders on frame, cross heads and guides not properly lined up, loose driving brasses, loose pistons, loose followers, piston traveling too far, etc.

Q.—96. How can a pound in driving box, wedge or rod brasses be located?

A.—Block wheels with engine on a quarter, give her steam and work the reverse lever to and fro. This will show any lost motion in wedges or rods or driving boxes.

Q.—97. When should driving box wedges be reported to be lined?

A.—When there is lost motion enough so they begin to pound.

Q.—98. When should driving box wedges be reported to be lined?

A.—When they do not set the box up tight, when they are screwed clear up.

Q.—99. When should rod brasses be reported to be filed?

A.—When driving the key down brings them line and line, or brass and brass together.

Q.—100. When should rod brasses be reported to be lined?

A.—When driving the key clear down does not bring the brass tight against the pin.

Q.—101. When should lost motion between engine and tender be taken up?

A.—Whenever there is any there.

Q.—102. Describe the principle on which an injector works.

A.—An injector is a device for forcing water into a boiler by means of a steam jet, which, upon coming in contact with the water at a point in the injector known as the "combining tube," loses its identity by condensation after giving the water sufficient velocity to cause it to enter the boiler against its (the boiler) pressure.

Q.—103. What is generally the cause of failure of the second injector, and what should be done to obviate the failure?

A.—Its failure to work when wanted is generally chargeable to the fact that it is not used often enough to keep it in working order. To remedy the cause it should be worked oftener.

Q.—104. What are the advantages of the combination boiler check?

A.—It has a hand valve that can be closed in case of check sticking open and will prevent the losing of the pressure.

Q.—105. If an injector stops working while on the road, what should be done?

A.—Start the other one, look at the tank valve to see if it is open. Know if there is water in the tank. See that strainer and feed pipe are open for free passage of water. Look for leaks in feed pipe. The tubes may be out of line or filled with lime or sediment or boiler check may be stuck shut.

Q.—106. How can a disconnected tank valve be opened without stopping?

A.—By blowing steam back through the feed pipe generally.

Q.—107. If the steam heat gauge showed the required pressure and the cars were not being heated properly, how should one proceed to locate the trouble?

A.—Open steam valve at rear of tank to ascertain that there were no obstructions in pipe on engine or tank, and if none and the gauge shows proper pressure the trouble would be on the train.

Q.—108. How does the steam heat reducing valve control the pressure?

A.—In the steam heat reducing valve there is a diaphragm which is held in position by a spring and which is connected directly to the steam admission valve from the boiler to the train pipe. The spring has tensions, which in turn holds the steam valve and is regulated by hand at any desired pressure, and any variation in the pressure will cause this to work as a regulator.

Q.—109. What constitutes abuse of an engine?

A.—Not paying attention to proper oiling of the parts, slipping the engine badly, careless or improper firing, which is liable to set flues to leaking, improper handling of the injector, letting the engine run with wedges down or rods pounding badly, or any thing of a like nature.

Q.—110. How are accidents and break-downs best prevented?

A.—By a close attention to business and careful inspection and use of good judgment in handling of the engine.

Q.—111. What are the duties to be performed by an engineman when giving up his engine at the terminal?

A.—Give the engine a thorough inspection and report all necessary work on work book.

Q.—112. In what manner should an engine be inspected after arrival at the terminal?

A.—A thorough inspection of every part of the engine is necessary to make sure the engine is in shape for another trip.

Q.—113. In reporting work on an engine is it sufficient to do it in a general way, such as saying "injector will not work, lubricator will not work, pump will not work, engine blows, etc.?"

A.—No, sir. It should be reported in detail, giving all and full particulars and making it as plain as possible where the trouble is and what caused it, to the best of your ability.

Questions and Answers on the Compound Locomotives.

Question—1. Wherein do compound locomotives differ from ordinary or simple engines?

Answer—The difference between a compound and a simple engine is the way in which the steam is used. In a simple engine it is used in only one cylinder, then exhausted to the atmosphere. In a compound engine there are two cylinders instead of one. One for high pressure and one for low pressure steam. Steam from the boiler first enters the high pressure cylinder, expanding part of its pressure there, then is exhausted or passes through some kind of a receiver into the low pressure cylinder, is again expanded in this cylinder to still a lower pressure, then exhausted to the atmosphere, thereby using the steam twice in the compound instead of once, as in the simple engine.

Q.—2. Why is one cylinder on the compound locomotive called the high pressure cylinder and the other one the low pressure cylinder?

A.—One cylinder is called the high pressure cylinder because it gets steam direct from the boiler. The other cylinder is called the low pressure cylinder because when the engine is compounded it gets its steam direct from the high pressure cylinder at a much lower pressure than the one that gets it direct from the boiler.

Q.—3. What is the principle advantage claimed for the compound locomotives?

A.—There are several. First, compounding an engine has been proven in stationary practice to give more economical results than using steam with single expansion. Therefore, it is reasonable to expect good results in locomotive service. Second, a more uniform crank pin pressure is obtained with a compound engine and there is less liability of the engine slipping, and an evener pull is developed when on a hard pull or moving slowly Third, the compounding of steam shows a greater saving in fuel by the fact that more power is developed from a given boiler capacity than if the steam was used by a single expansion or simple engine.

Q.—4. In the Schenectady two cylinder compound what is the duty of the oil dash pot?

A.—It prevents the intercepting valve from too rapid a movement in changing from simple to compound or back again so that it will not slam on its seat and cause injury to the parts.

Q.—5. Is it necessary to know that the oil dash pot contains sufficient oil, and why?

A.—Yes. The dash pot should be kept full of oil or the movement of the intercepting valve will not be regulated properly, caused by the air in the dash pot not forming sufficient cushion.

Q.—6. Explain how a Schenectady two cylinder compound may be operated as a simple engine.

A.—All that is necessary is to turn the handle of the emergency operating valve to the position marked simple. This will automatically admit boiler steam at reduced pressure to the low pressure cylinder and allow the high pressure exhaust to go direct to the stack. These engines should not be worked simple except when at very low speed and the lever in full gear.

Q.—7. When should a Schenectady compound be operated as a simple engine?

A.—When running slow on a hard pull, or when starting a heavy train or there is danger of stalling, and should be put back in compound as soon as speed picks up or danger of stalling is past.

Q.—8. Why not operate as simple when running faster?

A.—The ports are of such size that to run simple at any other than a slow rate of speed it will be choked and never run as well or use the steam as economically as to be compounded.

Q.—9. Explain how the two-cylinder compound engine is changed from simple to compound.

A.—When running simple move the handle of operating valve to the compound position. It will automatically change so as to use the steam on the compound plan.

Q.—10. What moves the intercepting valve in a two-cylinder compound?

A.—Steam pressure.

Q.—11. How should a compound locomotive be lubricated?

A.—There are extra pipes besides the usual ones to the cylinders from the lubricator for the reducing and intercepting valve chamber. Also a cup in the connection leading to the separate exhaust valve. While working steam about two thirds of the oil should go to the high pressure cylinder. About one drop per minute is enough for the reducing and intercepting valves. A little valve oil every four or five hours is enough for the separate exhaust valve.

Q.—12. Why feed more oil to a high than a low pressure cylinder?

A.—Because some of the oil for the high pressure cylinder will be carried with the exhaust steam to the low pressure cylinder, thereby assisting in its lubrication.

Q.—13. How much water should be carried in a boiler of a compound locomotive?

A.—It must not be carried too high so as to endanger its being carried over into the cylinder with the steam.

Q.—14. Why should no more than the amount which you answer for the preceding question be carried in the boiler of a compound locomotive?

A.—It would have a tendency to wash the lubricant

from the valves and walls of the cylinders, thereby increasing friction and perhaps cause the rings to break, or might knock out a cylinder head with the piston valve, and it is positively necessary to have dry steam to get good results from a compound engine, and the water should be carried low enough to insure this.

Q.—15. How should a compound locomotive be started with a long train?

A.—Reverse lever in full forward gear handle of starting valve in the simple positions, and starting train as with a simple engine. As soon as a speed of three or four miles an hour has been attained move the handle of starting valve to compound position and notch up reverse lever as train increases speed.

Q.—16. When drifting, what should be the position of the separate exhaust valve, cylinder and port cocks?

A.—The cylinder and port cocks should be shut. They are to get rid of the water at starting, not to act as a relief valve. It is a good plan to open throttle a little when drifting, it lubricates and makes the engine drift freer. The separate exhaust valve handle should be at simple position except when air leakage is too great.

Q.—17 What will cause two exhausts of air to blow from the three-way cock when the engine is being changed to compound?

A.—Moving the handle of three-way cock from simple to compound allows the air holding the valve open to escape, and when the valve closes it forces the remaining air out, causing two exhausts.

Q.—18. What does steam blowing at the three-way cock indicate?

A.—That there is a leakage by the packing rings of the piston of the separate exhaust.

Q.—19. What can be done if the engine will not operate as compound when air pressure on the separate exhaust valve is released by the three-way cock?

A.—It would indicate that the separate exhaust valve had not closed, and is often caused by improper lubrication and can often be remedied by giving the valve a

dose of coal oil, then when open oil properly with valve oil.

Q.—20. If the engine stands with the high pressure side on the dead center and will not move when given steam, where is the trouble and what may be done to start the engine?

A.—Either the reducing valve is stuck, closed, or the intercepting valve is stuck in the compound position, caused by water being carried too high, or a lack of oil. If the intercepting valve is clear, showing only about three inches, the reducing valve is stuck, but if it shows about seven inches it shows the intercepting valve is stuck in compound position. A few light taps will generally start it if the throttle is left open and there is nothing broken, and a few sharp blows on the back head with the throttle open will start the reducing valve, and if started in either case the engine will then be all O. K., if oiled at once.

Q.—21. Give reason for your reply to preceding question.

A.—With these valves stuck with high pressure side on center the reason for not moving is there is no way for steam to pass to the low pressure side to move the high pressure side off the center.

Q.—22. In the event of a break down, how should one disconnect?

A.—Never forget that by moving the separate exhaust valve to simple position, the engine is made to work as a simple engine, so if a compound engine, even though the engine must be disconnected on one side, the break-down can be treated like it would be were the engine a simple engine, and no matter whether the break-down be on the high or low pressure side the moving of the separate exhaust valve to the simple position will allow either the high or low pressure cylinder to take steam and exhaust it as a simple engine would.

Q.—23. What may be done to shut off steam pressure from the steam chest and low pressure cylinder?

A.—Remove the intercepting valve from its cham-

ber and block the reducing valve so that when the intercepting valve is replaced it will be shut and steam can not be admitted to the engine.

Q.—24. Is it important that air be pumped up on a Schenectady two-cylinder compound locomotive before engine is moved?

A.—It is.

Q.—25. Why?

A.—Because the separate exhaust valve is moved by air pressure and the engine can not be changed from compound to simple unless this valve works, and if the engine stopped with the high pressure side on the dead center, or if you had any heavy work to do, the engine could not be handled properly.

Q.—26. How are blows in a compound located?

A.—When working the engine simple a blow in the valves or cylinder packing can be tested for the same as a simple engine is tested. If the emergency exhaust valve is leaking a steady blow can be heard at the stack between the exhausts when working compound. A good test for leakage by the intercepting valve packing rings is to block the wheels and put separate exhaust valves in simple position and open the throttle and a blow at the stack, providing the high pressure valve and cylinder packing are tight will indicate a leakage by these rings. A leak by the packing rings of the reducing valve will be indicated by steam showing at the drip pipe in the reducing valve chamber.

Q.—27.—To what ports are the by-pass valves connected, and why are they used?

A.—The by-pass valves are used to relieve the cylinder of any pressure that may be produced in them when the engine is drifting. In the Schenectady compound these valves are held to their seats by the steam pressure from the steam chest as long as the throttle is open, but when drifting, any pressure found in the cylinder will raise them, and when raised there is a direct communication from one end of the cylinder to the other by these valves.

Questions on the Schnectady Tandem Compound Locomotive With Answers Appended.

Question—1. Why are the four-cylinder Schenectady compound locomotives called tandem compounds?

Answer—The word tandem means one after another, and in this class of engines the low pressure cylinder is placed behind the high pressure, one on each side of the engine. The two pistons are mounted on the same rod, thereby calling in use the word tandem.

Q.—2. Does the steam in a tandem compound. locomotive exhaust from left to right cylinders in a similar manner to the cross compound?

A.—No, sir.

Q.—3. Are the valves on a tandem compound locomotive designed to give outside or inside admission of steam?

A.—Both the low pressure valves give outside admission and the high pressure valve gives inside.

Q.—4. What arrangements of steam ports have these engines so that an outside and inside admission valve may be operated by one valve rod?

A.—The steam ports from the high pressure steam chest to the high pressure cylinder are crossed by each other. The front port leading to the back of the cylinder and the back port leading to the front of the cylinder. The steam ports in the low pressure steam chest are direct, thereby allowing one valve rod to properly operate both an inside and outside admission valve.

Q.—5. Trace the course of the steam from the high pressure valve to the atmosphere when working compound.

A.—It must be remembered that the high pressure valve is an inside admission and that the steam ports to the high pressure cylinders cross each other. Also that both the high and low pressure valves are hollow and are

both connected by one rod and are in a common steam chamber. Also that the low pressure valve has an outside admission and has direct ports. Steam pressure from the boiler through the steam pipe surrounds the high pressure valve between its heads, and as the valve moves ahead the steam is admitted to the front steam port and passes to the back end of the high pressure cylinder. Any exhaust steam in the forward end of the high pressure cylinder passes out the back port, which is uncovered when the valve moves ahead, and passes into the common steam chamber in which both hollow valves move. The low pressure valve being connected on the same valve rod as the high pressure valve, moves ahead with this valve, and having an outside admission opens the port to the back end of the low pressure cylinder and the high pressure exhaust passing through the hollow valve and the back steam port acts on the back of the low pressure piston. The steam in the front end of the low pressure cylinder going direct to the exhaust. On the return stroke the valves move back. Steam is admitted through the back steam port to the front end of the high pressure cylinder, and is exhausted from the back end of the high pressure cylinder through the front steam port and passes through the hollow high pressure valve and is admitted to the front end of the low pressure cylinder, the steam in the back end of the low pressure cylinder being exhausted direct to the stack, thence out.

Q.—6. When and how may a tandem compound be operated as a simple engine?

A.—Place the starting lever in cab in simple position, thereby admitting live steam to both the high and low pressure cylinders. It should only be done when starting a train or when on a hard pull, and then not any longer than necessary.

Q.—7. What steam passages have communication with the starting valves?

A.—Both the back and front steam ports to the high pressure cylinder.

Q.—8. How does manipulation of the starting valve cause the engine to operate as simple?

A.—Pulling the starting valve lever in simple position opens a valve which admits steam directly from the steam chamber of the chest to the bottom of the by-pass valves. This pressure raises the by-pass valves and opens direct communication from one high pressure steam port to the other. This allows boiler pressure to act on the high pressure corresponding side of the low pressure piston, causing the engine to work boiler pressure steam in both cylinders.

Q.—9. What other valves are in the starting valve casting?

A.—The by-pass valves.

Q.—10. How many sight feed lubricators have a tandem compound, and what do they lubricate?

A.—They usually have five sight feeds, and they lead, one to each high and one to each low pressure cylinder and one to the air pump.

Q.—11. How should the oil used be distributed?

A.—When working steam about two-thirds of the oil should go to the high pressure cylinders, and when drifting, right the reverse, and the air pump its usual allowance.

Q.—12. How should a Schenectady tandem compound be disconnected in case of break down on the road?

A.—The same methods that are applied to a simple engine as regards the removal of parts, the blocking of cross heads, and clamping of valves.

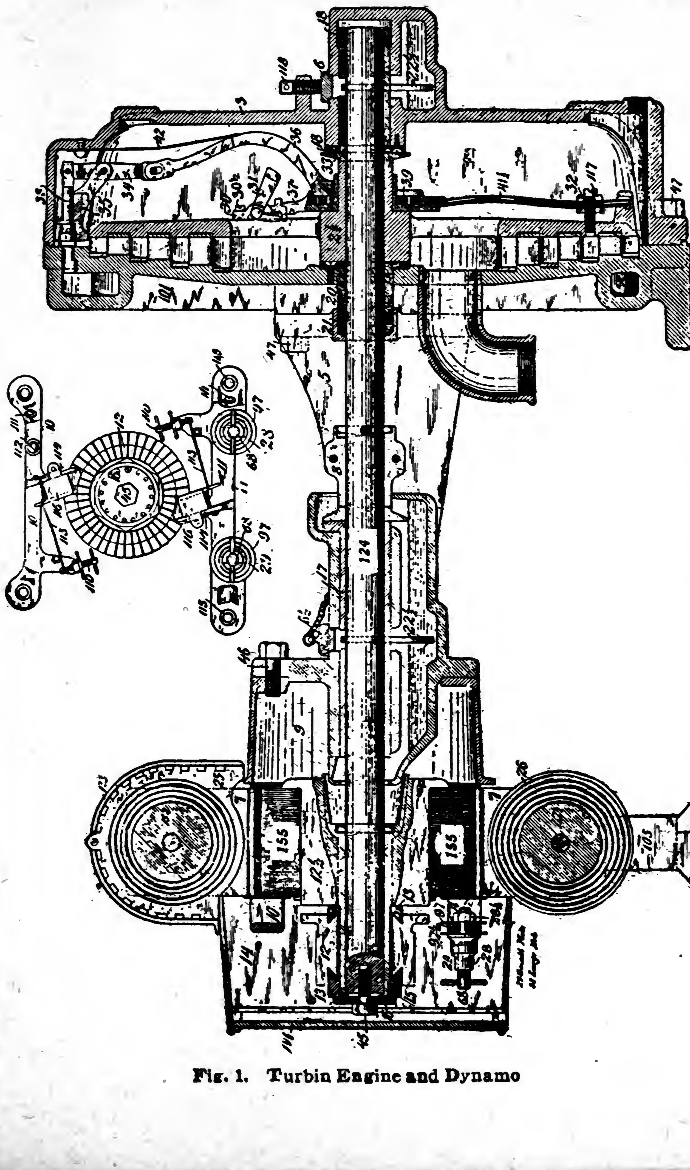


Fig. 1. Turbin Engine and Dynamo

List of Parts of Turbin Engine and Dynamo

1. Main Casting, 4 rows buckets.
2. Wheel, 5 rows buckets.
2½. Wheel, 3 rows buckets.
3. Engine Cap.
5. Box Yoke.
6. Oil Cover, outside.
6½. Oil Cover, inside.
7. Pole Pieces.
8. End Thrust.
9. Brass Yoke.
10. Top Brush holder.
11. Bottom Brush holder.
12. Commutator.
12½. Armature Spider.
13. Commutator Ring.
14. Dynamo Door.
14½. Name Plate.
15. Commutator Nut.
16. Outside Washer.
17. Long Bushing.
18. Short Bushing.
20. Stuffing Box.
21. Gland Nut.
22½. Oil Ring.
25. Top Field Washer.
26. Bottom Field Washer
27. Dynamo Feet, old style.
28. Binding Post, large hole.
28½. Binding Post Nut.
29. Binding Post, small hole.
30. Governor Weight Clamp.
30½. Governor Saddle Screw.
31. Governor Weight.
32. Spring Clamp.
33. Cast Iron Washer.
34. Connecting Link.
35. Governor Stand.
36. Cross Arm.
37. Center Piece.
38. Bronze Plunger.
39. Graphite Ring.
41½. Governor Springs.
42. Cap Spring.
45. Armature Lock Screw
46. Cap Screw.
47. Cap Screw.
68. Binding Post Screw.
97. Insulation Washer.
97½. Insulation.
101. Main Casting.
105. Dynamo Foot.
110. Brush Spring Adjusting Screw.
111. Connecting Screw for Inc. Wire.
112. Connecting Screw for Upper Field.
113. Brush Spring.
114. Brush Clamp Spring.
115. Insulating Bushing.
116. Brush Clamp Adjusting Screw.
117. Governor Spring.
118. Oil Cover Set Screws.
123. Top Field Cover.
124. Main Shaft.
152. Top Field Complete.
152½. Bottom Field Complete.
155. Armature.

THE PYLE NATIONAL ELECTRIC HEADLIGHT

In taking up the subject of electric headlights, I have thought it best to put it in the form of a list of questions along with the answers under each question. using such questions as are apt to be asked by the examiner on railroads where the electric headlight is in use. Along with the questions and answers, I will give illustrations and names of the different parts of the Pyle National Electric headlight, hoping they will assist the student and perhaps give a few pointers to those who may come in contact with them as operators of them, along with their other duties as engineers and firemen.

Question 1.—What is an electric headlight?

Answer.—A device applied to the front of a locomotive and used to illuminate the track by means of a light produced by a current of electricity.

Q.—2. What principal parts comprise the Pyle National Electric headlight?

A.—The turbine engine, the dynamo and the arc lamp.

Q.—3. What are the duties of the turbine engine?

A.—The turbine engine furnishes the mechanical power that operates the dynamo, the latter producing the light.

Q.—4. What are the principal parts of the dynamo?

A.—The armature, the commutator (which is attached to the armature shaft), the two field magnets and the pole pieces.

Q.—5. What are the duties of the armature?

A.—The armature induces an electromotive force in the copper wires wound upon it, and concentrates and directs the flow of current.

Q.—6. What is the function of the commutator?

A.—The function of the commutator is to collect the currents produced by the armature wires and cause them all to concur to a desired result.

Q.—7. Where is the commutator attached to the armature?

A.—It is attached to the end of the armature shaft, so that it rotates therewith.

Q.—8. How is the commutator formed?

A.—The commutator is formed of alternating sec tions of conducting and non-conducting material, running lengthwise upon the axis upon which it turns.

Q.—9. What is the function of the field coils or magnets?

A.—The function of the field magnets is to produce an intense magnetic field in which the armature revolves.

Q.—10. What are the pole pieces and their function?

A.—The pole pieces are the end portions of the field magnet and they form the armature chamber in which the armature revolves.

Q.—11. What are the first three measurements of electricity?

A.—The volt, the ampere and the ohm.

Q.—12. What is a volt?

A.—The volt is the practical unit of measurement of **electrical pressure.**

Q.—13. What is an ampere?

A.—The ampere is the practical unit of measurement of the **rate of flow of current.**

Q.—14. What is the ohm?

A.—The ohm is the unit of **electrical resistance,** such a resistance as would limit the flow of electricity under an electro-motive force of one volt to a current of one ampere.

Q.—15. Where is electricity found?

A.—Electricity is everywhere—it pervades all bodies.

Q.—16. Does electricity itself represent weight?

A.—It does not. Electricity, being intangible and having no substance, cannot have weight nor occupy space.

Q.—17. How is electricity conducted into houses or from the dynamo to the lamps?

A.—By means of copper wires.

Q.—18. What prevents electricity from escaping?

A.—To prevent the escape of electricity the wires are covered or insulated with various substances, such, for instance, as rubber, asbestos, etc.

Q.—19. What causes the water to flow through the pipes into our houses when we open the faucets or valves?

A.—Pounds pressure, or head.

Q.—20. If the pounds pressure in the pipes should become too great, what would result?

A.—The pipes would burst and the water escape.

Q.—21. What causes the electricity to flow through the wires and lamps?

A.—The electro-motive force, or voltage.

Q.—22. What produces the electro-motive force, or voltage?

A.—The electro-motive force, or voltage, is produced in the armature wires by the armature revolving in its chamber at a very high rate of speed.

Q.—23. What causes the electrical pressure, or voltage, to become too high?

A.—By increasing the speed of the armature beyond the point desired.

Q.—24. Then the speed at which the armature revolves determines the amount of voltage produced?

A.—Yes.

Q.—25. Should the electrical pressure become too great, what would result?

A.—If the electrical pressure, or voltage, becomes too high, the wires conducting the current will be heated so hot that the insulation wound upon them will become charred.

Q.—26. When the insulation on the wires becomes charred, does it lose its virtue?

A.—Yes. When the material covering the wires becomes charred, it is no longer a good insulator, and

the current will leak through from layer to layer of the coils.

Q.—27. What is this called?

A.—A burned out coil.

Q.—28. Does the volt represent any electricity?

A.—It does not. It represents only the pressure that acts upon the electricity.

Q.—29. What effect has the volt upon a current of electricity?

A.—It forces a quantity of current to flow through the wires at a certain rate per second.

Q.—30. How is this rate of flow measured?

A.—In amperes.

Q.—31. How do we make a current of electricity do work for us?

A.—By placing opposition in its path.

Q.—32. Do the wires through which the current passes offer any resistance to its flow?

A.—Yes. These solid wires offer a certain amount of resistance to the passage of electricity, just as the water pipe does to the water. The effect of the resistance to the passage of electricity is greater if a large quantity is passed through than a smaller quantity.

Q.—33. How many paths does electricity take?

A.—Electricity takes as many paths as are offered, but it always takes the easiest path, or the one offering least resistance.

Q.—34. What is meant by a short circuit?

A.—A short circuit is a passage offered whereby a quantity of current of electricity may flow with less resistance than is offered by its passage to points desired, such as lamps, etc.

Q.—35. What is the cause for most of the short circuits found in this device?

A.—Distorted insulation of wires, brought about by chafing.

Q.—36. How may this be avoided?

A.—By properly protecting the wires when an equipment is applied.

Q.—37. How should the wires be run from the dynamo to the lamp when the dynamo is applied near the cab of the locomotive?

A.—When the dynamo is applied near the cab the wires to the arc lamp should be run through a separate pipe and inside of a molding.

Q.—38. Why is it not good practice to place these wires inside of the hand railing?

A.—There are several reasons. First, when there is stay bolt work to be done, often the handrail must come off, and the boilermakers might not use the greatest care in removing same, and so damage the insulation on the wires, and this might not be observed until a failure had resulted. Second, there is great danger of the insulation being chafed off or the wire broken where they enter or leave the hand railing, on account of the abrupt angle at which the wires are bent. Third, water may get inside of hand railing and not drain out, and this would in time moisten and rot the insulation until the water could soak through, and when the insulation has become moist it has lost its virtue as an insulator.

Q.—39. How should the wires be run to the arc lamp when the dynamo is applied at the front or on the arch of the locomotive?

A.—When the dynamo is applied on the arch of the locomotive, the wires should be run through a piece of circular loom, or a piece of rubber hose, and this conduit passed through to inside of reflector cage.

Q.—40. How should wires be run to lamps in the cab of the locomotive?

A.—Wires to cab lamps should be run from the dynamo into the cab through an iron pipe or a piece of circular loom conduit and under a molding in the top of the cab. If the iron pipe is used, the wires must

be thoroughly wrapped with insulation tape where they enter and leave pipe.

Q.—41. By what name is the engine that furnishes the mechanical power that operates the dynamo known?

A.—The Pyle compound steam turbine.

Q.—42. Explain the construction of this engine and the passage of steam through same.

A.—The engine consists of a main casting having three rows of exhaust or receiving buckets. The turbine wheel revolving in this casting has three rows of bottomless buckets or blades that are solid, cast in the wheel and fitted in a recess in the main casting in such a manner that the steam may pass from the blades of the wheel to exhaust buckets of casting and back into the next row of bottomless buckets in wheel, and so on until the final exhaust into a central chamber, thence to the atmosphere (as shown in Fig. 2).

Q.—43. Does this turbine engine require any internal lubrication?

A.—It does not.

Q.—44. Why?

A.—This engine has no reciprocating parts, and therefore requires no internal lubrication.

Q.—45. By what mechanical means is the speed of this device controlled?

A.—By a governor applied within the casing of the engine.

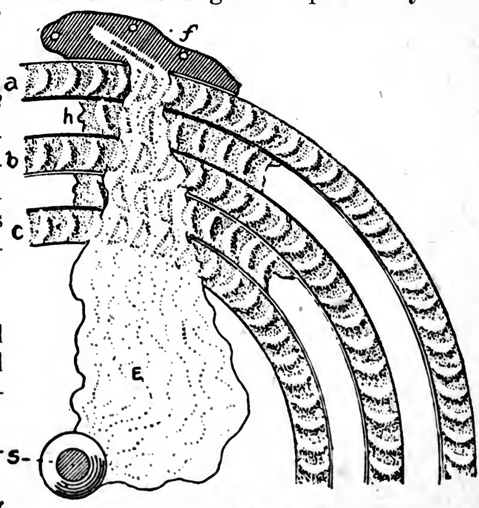


Fig. 2

Q.—46. What style of governor is used?

A.—A centrifugal governor.

Q.—47. Is there any other means employed within this turbine to prevent the speed attaining a velocity beyond the point desired?

A.—Yes. There is a centrifugal brake applied to the turbine wheel and set so that it will act at about 150 revolutions higher speed than the point at which the governor is set to act.

Q.—48. Why is this centrifugal brake not adjusted so that it will act at the same speed as the governor?

A.—There are two reasons why the brake is not set so that it will act in conjunction with the governor. First, the brake will not act as quick as the governor weights, and would therefore interfere seriously with the speed at the critical time. Second, it was designed and applied to prevent any possibility of the turbine wheel running away and being thrown to pieces by centrifugal force at times when the governor plungers have been neglected.

Q.—49. How many governor weights are there in this device?

A.—Four in number.

Q.—50. How many sets of governor springs are used and what is their duty?

A.—There are four sets of governor springs used, and their duty is to offer the proper amount of resistance to the movement of the governor weights and to cause them to act quickly.

Q.—51. How many governor valves, and where are they located?

A.—There are two governor valves, and they are placed within the governor stands.

Q.—52. Where are the governor stands located? (We show the governor stands in Fig. 3.)

A.—The two governor stands are suspended to the main casting and at diametrically opposite points.

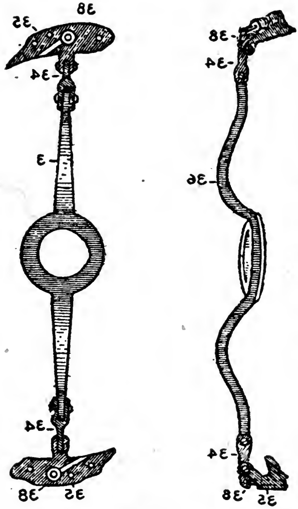


Fig. 3

Q.—53. When the steam is turned on and the turbine wheel is given motion, what effect has this on the governor weights?

A.—When the turbine wheel is started in motion the governor weights, being attached thereto and revolving about the vertical axis of the shaft, tend to fly farther apart.

Q.—54. This action of the governor weights causes what?

A.—This movement of the governor weights forces the cross arm out, which in turn moves the two governor plungers in towards their seats, thereby diminishing the volume of steam that is flowing to the turbine wheel.

Q.—55. If the governor weights are allowed to travel out farther than at right angle position to face of the turbine wheel before the governor plungers are seated, will the governor be able to control the speed?

A.—No.

Q.—56. How often should the governor plungers be examined to insure ideal service?

A.—At least once a month by a competent inspector.

Q.—57. When the governor has been properly set, how long will this device run before the plunger valves may need facing?

A.—At least six months.

Q.—58. Is it not possible to ascertain whether the plungers are stuck or not without removing the engine cap?

A.—No; not in all cases, though if one of the valves is stuck wide open, or entirely shut, it can be determined by taking the speed with the load on, then with the turbine without the load.

Q.—59. What lubricates the center piece and face of cross arm?

A.—The graphite ring.

Q.—60. Describe this ring and its location.

A.—The ring known as the graphite ring is a flat bronze ring that is drilled full of holes, and these holes are filled with graphite. This ring is held in a small recess in the center piece by the cross arms.

Q.—61. How can the speed of the turbine and dynamo be increased when all parts are normal?

A.—The speed of this device can be increased by moving all of the governor spring adjusting screws to the right.

Q.—62. How may the speed be reduced?

A.—By moving all governor spring adjusting screws to the left.

Q.—63. To increase the speed of dynamos 100 revolutions per minute, how far should the screws be turned?

A.—Move all the adjusting screws one-half turn to the right.

Q.—64. To decrease speed?

A.—Move one-half turn to the left.

Q.—65. What should always be done just before engine cap is removed?

A.—The end thrust should always be adjusted to 1-32 of an inch before the engine cap is removed.

Q.—66. Why?

A.—If it is found that some changes are necessary in governor, such as changing cross arms, etc., unless

the end thrust is adjusted **before** such changes are made, there is great danger that the travel of the plunger valves might be cut off, perhaps entirely closed.

Q.—67. How is adjustment of end thrust made?

A.—When facing the dynamo by first loosening screws in end thrust casting, then tapping same on left side will take up end movement, and by tapping on right side will increase end movement.

Q.—68. When it is found that the turbine wheel has been carried too far away from the governor stands (due to end thrust movement), to direct the steam against the center of the bucket in wheel, what is the cure?

A.—It will require a new bushing in engine cap and a new cast iron washer.

Q.—69. If there are no new parts at hand to make repairs, what may be done?

A.—Temporary repairs can be made as follows: First, loosen screws in end thrust casting and move the latter to the right, then move the wheel in towards the main casting as far as it will go. Now place a metallic washer of some kind between the flange of the bushing in engine cap and the cast iron washer, being careful that this washer is only of sufficient thickness to take up the lost motion between flange of bushing and cast iron washer.

Q.—70. Is it not quite clear to you that changing the tension of the regulating springs will not always influence the speed of the turbine and dynamo to any marked degree?

A.—Yes, sir, it is.

Q.—71. Where is the centrifugal brake applied?

A.—The centrifugal brake is applied on the back side of the turbine wheel.

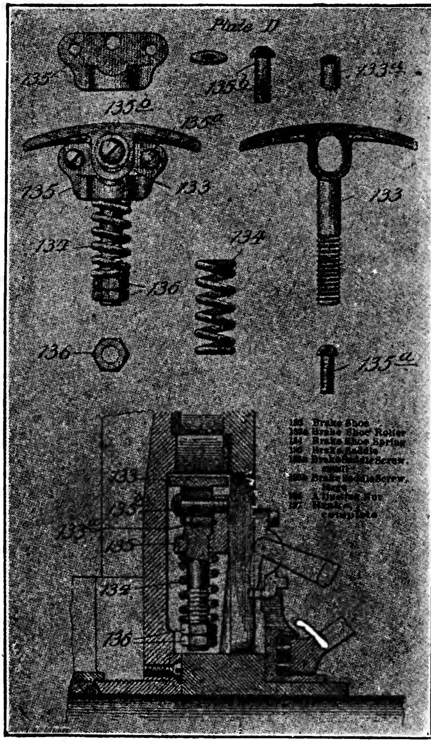


Fig. 4. Centrifugal Brake

Q.—72. How is this brake adjusted?

A.—To adjust centrifugal brake, remove the armature, engine cap and governor, pull out wheel and shaft, when you will have free access to the brake.

Q.—73. How can you adjust brake to act at a lower speed than where it may be set to act?

A.—By turning all of the adjusting nuts to the left.

Q.—74. To act at a higher speed?

A.—Turn all adjusting nuts to the right.

Q.—75. To change the adjusting nuts on centrifugal brake one-half turn, either to the right or left, changes the point at where brake will act, how much?

A.—One-half turn of all nuts will change speed at which brake will act 150 revolutions per minute.

Q.—76. If correct travel of governor plungers is maintained, will it often be found necessary to readjust the brake?

A.—No; seldom, if ever.

Q.—77. How is the cast iron washer secured so that it will revolve with the turbine wheel shaft?

A.—The cast iron washer 33 is sustained by a small dowel pin that is made to enter the hub of the turbine

wheel, thereby causing the former to revolve with the turbine wheel shaft.

Q.—78. Do these small dowel pins ever break off?

A.—Yes, quite often.

Q.—79. What is the cause of dowel pins breaking?

A.—Running the equipment with too much end thrust, thereby allowing the washer to move the dowel out of recess. Also, maintaining the end thrust too close with insufficient lubricant.

Q.—80. When the dowel pin breaks, what results?

A.—With the pin broken off, the washer cannot revolve with the wheel, but is loose on the shaft, and the hub of the turbine wheel, now chafing the thin back surface of the washer, soon increases the end thrust beyond point desired.

Q.—81. Should the end thrust be taken up when the equipment is cold?

A.—Yes. The adjustment of end thrust should be made when the equipment is cold; then, when heated up and expansion takes place, it will not be too tight, if adjusted to 1-32 of an inch.

Q.—82. Should the end thrust casting, with which adjustment of this movement is made, become loosened on shaft, what would result?

A.—When facing the dynamo the armature and shaft turn to the right. To take up or decrease the end movement, this end thrust casting is moved in the opposite direction. Should the screws that secure this casting to the shaft become loosened, the shaft, revolving at a very high rate of speed, would tend to run away from the adjustment casting. This casting is a worm screw device, and would move up on the shaft until its own flange and the cast iron washer in engine would be carried hard against flange of bushing, and the engine would stall.

Q.—82. How may an engineer locate this trouble instantly?

A.—When the turbine engine is stalled by this casting, the steam will blow very hard at the exhaust,

and it will be impossible to move armature by hand, as can easily be done at all other times.

Q.—83. When this occurs, what should be done?

A.—Move end thrust casting to the right (when facing the dynamo) until the engine is free, then tighten screws, first being sure to adjust end movement to 1-32 of an inch.

Q.—84. What precaution may be taken that will tend to prevent the governor plungers from sticking?

A.—If the ¾ inch plug at top of engine casting is removed each trip before starting, and a small amount of coal oil or black oil introduced at this point, when steam is turned on to turbine engine, this oil will be blown through the governor stands and around plunger valves, and will cut away any scale that may have started to form, thereby preventing their sticking.

Q.—85. Is it necessary to introduce oil at this point to lubricate the turbine engine or the plunger valves?

A.—No; as there are no reciprocating parts within this engine, it requires no internal lubrication.

Q.—86. How many bearings are there within this device?

A.—There are two bearings.

Q.—87. Where are these bearings located?

A.—One, the shorter bearing, is located in the engine cap casting, and supports the weight of the turbine wheels; the other, and longer, or main bearing, is placed in the box yoke 5, and carries the weight of the armature.

Q.—88. How are these bearings lubricated?

A.—Each of these bearings is provided with an oil cellar, into which there is a small loose ring suspended around the shaft, a part of the top of each bushing being cut away to allow this oil ring to turn on shaft. As the shaft revolves, this loose ring is carried around, and passing through the oil in the oil cellar, carries this oil up to top of shaft, where it passes through the grooves in bushings to the bearings proper.

Q.—89. What kind of oil should be used in the small bearings in engine cap?

A.—Valve or cylinder oil should always be used in this bearing.

Q.—90. How often should this bearing be oiled?

A.—Just before starting the engine, or at the beginning of each trip.

Q.—91. What should always be done just before oil is introduced into this cellar?

A.—The drain cock should be opened and the water of condensation that is always found in this cellar drained off, and then it should be **known** that the drain plug is closed tightly before the oil is put in the cellar, or the oil will leak out, with the result that the bushing and shaft would be destroyed in short order.

Q.—92. What grade of oil should be used in the main bearings in box yoke?

A.—The best results are obtained by the use of black or engine oil in this bearing.

Q.—93. How long will this main bushing run without renewal if properly lubricated?

A.—If regularly oiled with proper lubricant, this bushing will run at least two years.

Q.—94. How much oil should be used in this main bearing?

A.—No more than enough for the loose oil ring to trail in.

Q.—95. How often should this main bearing be oiled?

A.—It should be examined each trip, but it is seldom found necessary to oil more than twice a week.

Q.—96. What is the maximum speed at which it is intended that this turbine engine should run?

A.—The maximum speed is 1,800 revolutions per minute.

Q.—97. What is the minimum speed at which it may be run?

A.—To insure a good light at all times, the minimum speed of this engine and dynamo should not be below 1,650 revolutions per minute.

Q.—98. . When starting the equipment in operation, what precaution should be observed, and why?

A.—When it is desired to start the electric headlight, the throttle to steam turbine should be opened slowly in order that the steam may gradually heat the pipes and engine, also to allow the water of condensation to pass out of pipes and casting.

Q.—99. How is the armature made to revolve?

A.—By being attached to the engine shaft.

Q.—100. How is the armature held in place on the engine shaft?

A.—The armature is held in place by one screw, which can easily be removed if occasion demands.

Q.—101. How many brushes are used with this dynamo?

A.—Two.

Q.—102. Can the brushes be taken out and replaced, or trimmed, without changing the tension of the springs?

A.—Yes.

Q.—103. How many styles of brush holders are there in use on the Pyle national dynamos?

A.—Two at the present time; one with the flat straight bar spring, which is the old style, the other being a coil spring.

Q.—104. How is the brush adjustment made with the old style holder?

A.—Through the medium of adjusting screw 110.

Q.—104. Can the brush tension be changed at will of engineer?

A.—Yes, but with the old style of brush holder only, as the new brush holder is designed and supplied with a coil spring, and this spring is set or fixed with a predetermined pressure upon the brush, such that will maintain sufficient pressure upon the brushes to prevent sparking until brush is worn out, and the tension of these springs cannot be changed without first removing adjuster screw and spring adjuster, and this

can only be accomplished by the aid of a heavy screw-driver.

Q.—105. What is usually the cause when sparks are seen at the brushes?

A.—When sparks are seen at the commutator of this device, it is almost invariably because of an imperfect contact between the commutator and the brush.

Q.—106. With the old style brush holders, when sparks are seen at the commutator, what should be done?

A.—It should first be known that the commutator is clean and free from dirt. If clean and sparks are seen, the brush that is sparking must be tightened only until sparks are no longer seen. This is accomplished by turning screw 110 to the right.

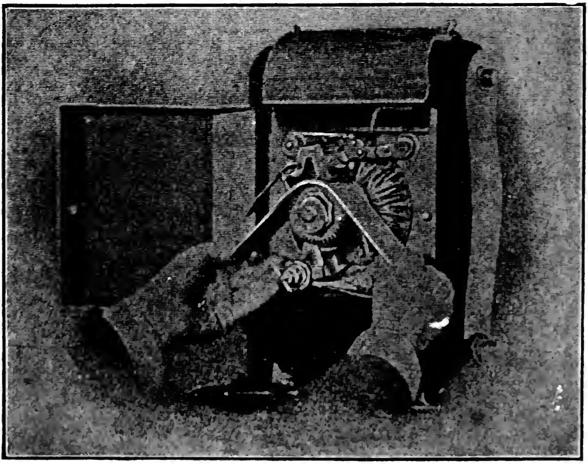


Fig. 5. Method of Using Sandpaper

Q.—107. With the new style brush holder, if sparks are seen at the brushes, what should be done?

A.—When sparks are seen at the brushes with the new style holder, it is almost invariably caused by dirty

commutator or brush, and the dynamo should be stopped and the commutator cleaned.

Q.—108. How should the commutator be cleaned, and what with?

A.—The commutator should always be cleaned with a damp cloth, or piece of waste, rubbing lengthwise of bars, and after washed clean, dried with a clean cloth or piece of waste.

Q.—109. If after cleaning it still sparks, what should be done?

A.—If brushes are clean, sparking is then caused by an imperfect contact between the brush and the commutator, and they must be cleaned with a piece of number O sandpaper.

In cut Fig. 5, we show method of using sandpaper in cleaning commutator.

Q.—110. How would you clean commutator with sandpaper?

A.—Remove both brushes. Take a strip of number O sandpaper about the width of the brushes, holding paper by the ends while the commutator is running. working the sandpaper back and forth lengthwise of the commutator so as to cover the entire surface until the commutator is perfectly smooth.

Q.—111. What is the correct pressure of the brush against the commutator?

A.—Correct pressure is attained when the brushes collect the full strength of the current without sparking, while the pressure on the commutator is just sufficent to overcome any vibration due to its rotation or the jar of the locomotive.

Q.—112. What will be the appearance of the commutator and brushes when their contact is perfect?

A.—When the brushes are worn to a smooth and polished bearing and the commutator takes on a high, dark cherry polish, the contact is perfect.

Q.—113. What are the wires that conduct the current to and from the arc lamp called?

A.—They are called the main or lead wires.

Q.—114. How are these lead wires connected to the dynamos and lamp?

A.—They are connected to the dynamo by binding posts that are held by the bottom brush-holder, and to the lamp by binding posts of like form that are secured to the lamp column.

Q.—115. When the wires are connected up properly, how must the current pass through the lamp?

A.—The current flows from one of the brushes of the dynamo around the field coils, into the positive wire (which is connected to the binding post with the large hole), through the positive binding post at the lamp and wire to top bracket of lamp, then through the top carbon into lower carbon, or copper electrode through the wire that is connected to the lower clamp to solenoid coil and to negative binding post on lamp, and into negative wire to the negative brush, which returns the current to the armature.

Q.—116. When is a circuit said to be closed?

A.—When it forms a continuous conducting path.

Q.—117. When is a circuit said to be open?

A.—A circuit is open when a discontinuity occurs in such a manner that an electric can not flow.

Q.—118. What are the duties of tension spring 93.

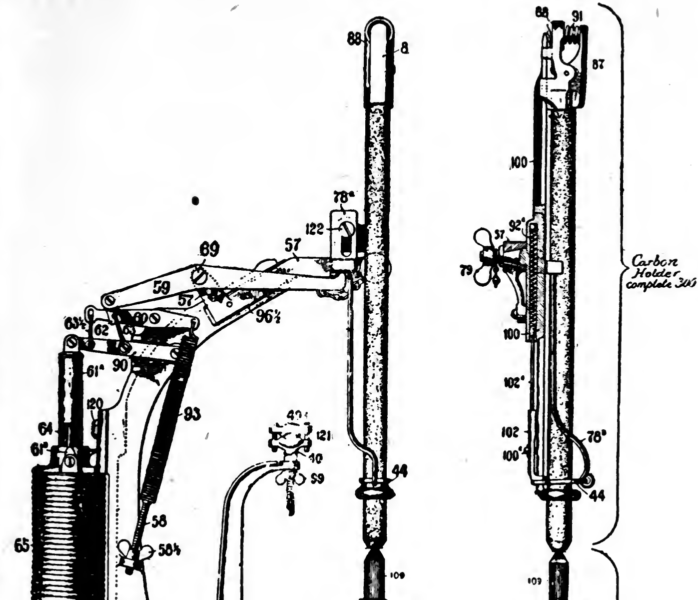
A.—They are two-fold. First it serves to bring the levers and clutch in such a position that the two carbon points come together, thereby closing or forming the circuit. Second, it serves to prevent the magnetism of the solenoid from pulling the iron magnet 64 down too far, thereby separating the carbons so far apart that the circuit would be broken and the light would go out.

Q.—119. How is an electric spark or light produced?

A.—It is produced by offering opposition or resistance to the easy passage of an electric current.

Q.—120. How is the arc produced?

A.—It is produced by bringing the points of the two carbons in contact with each other until a current



The Lamp Fig. 6

LIST OF PARTS OF LAMP.

Number.

28. Binding Post, large hole.
28½. Binding Post Nut.
29. Binding Post, small hole.
40. Reflector Clamp, bottom.
40½. Reflector Clamp, top.
41. Reflector Support.
44. Clutch.
49. Extension Base.
50½. Lamp Base.
51½. Lamp Column.
52. Bottom, large clamp.
53. Bottom small clamp.
54. Hand Nut.
55. Hand Washer.
57. Top Bracket.
58. Spring Tension Screw.
58½. Spring Tension Screw Nut.
59. Top Lever.
60. Small Lever.
61-a. Dashpot.
61-b. Dashpot Plunger.
62. Magnet Insulation.
63. Magnet Long Link.
63½. Magnet Short Link
64. Magnet.
65. Solenoid.
68. Binding Post Screw.
69. Top Lever Screw.

Number.

74. Set Screw.
78-a. Clutch Rod Weight.
78-b. Clutch Rod.
79. Thumb Nut.
81-a. Thumb Screw.
87. Carbon Clamp, male.
88. Carbon Clamp, female.
90. Magnet Yoke.
91. Carbon Holder Spring.
92-a. Top Clutch Spring.
93. Tension Spring.
96. Insulation Fibre.
97. Insulation Washer.
98. Vertical Adjusting Screw.
99. Vertical Adjusting Nut.
100. Upper Carbon Holder.
102. Clutch Foot.
102-a. Clutch Foot Rod.
106. Electrode Support.
107. Electrode Set Screw.
108. Electrode Lock Nut.
109. Copper Electrode.
120. Solenoid Screw.
121. Reflector Clamp Screw.
122. Clutch Weight Screw.
200. Electrode Holder Complete.
300. Top Carbon Holder Complete.

is established. When they are drawn a short distance apart by the mechanism of the lamp.

Q.—121. What is the operating mechanism of this lamp that causes the arc to be produced and maintained?

A.—The operating mechanism of this lamp is composed of a solenoid and magnet that are attached to the levers and clutch. The strength of the magnet growing weaker as the arc grows longer. At a certain point this magnet becomes weak enough to release the clutch that holds the carbon, and allows the latter to drop of its own weight toward the electrode. Before the carbon can drop to the electrode, however, the current through the magnet is strengthened and the downward motion of the carbon is arrested. Following is a cut of the lamp and a list of the names of different parts of same.

Q.—122. How long should the top or positive carbon burn?

A.—It should burn between eight and nine hours when speed of dynamo is about 1,800 revolutions per minute.

Q.—123. If the tension of clutch spring 91-a becomes weakened what effect will that have on the light produced?

A.—If spring 91-a is too weak it will allow the heel of the clutch to be jarred up when speed of engine is high and will cause a short circuit.

Q.—124. What is the cause if the light goes out when the locomotives is at rest?

A.—there are three things that will cause the light to go out when the locomotive is stopped at a station. If the tension of spring 93 is too weak the light will go out or flash badly when locomotive is stopped. If the carbon is not straight and round it will be held up in the clutch and the light will go out. But the most common cause for the light going out when engine is stopped is a dirty sticky dashpot plunger.

Q.—125. How can an engineer determine between the evils named?

A.—If the tension spring is too weak the light will flash and flicker very badly when the speed of the locomotive is high. To determine between a dirty dashpot plunger and an imperfect carbon. If when placing the fingers on the governor yoke and moving same down until lost motion is taken up between levers and clutch point against carbon. When releasing, if the clutch point falls quickly to the point of rest, the trouble is in the carbon. Otherwise it is caused by a dirty dashpot.

Q.—126. What is the correct position for the iron magnet in the solenoid?

A.—When the magnet yoke is pulled down against the bottom lug on the lamp column it should be three-fourths of an inch from the bottom of the solenoid to the bottom of the iron magnet.

Q.—127. Is it important to know that the end of the lever 59 is under the clutch rod weight 78-a.

A.—Yes. If the end of this lever was not under the clutch rod weight the carbon could not be lifted nor could the lamp operate.

Q.—128. When carbons are drawn from the store room what should be done to insure their feeding freely through the clutch when placed in the lamp?

A.—The top carbon holder should be removed from the lamp and the carbons drawn should be tried to determine if they will feed freely through the clutch when placed in the lamp.

Q.—129. When an engineer is called to go out on an engine equipped with an electric headlight what should he examine to know that this device is in good working order?

A.—First, he should drain the water of condensation from the oil cellar in the engine cap and oil this bearing with valve oil. Second, he should note if the loose ring suspended by the shaft and in the oil cellar of main bearing touches the oil, and if not, introduce enough engine oil so that it will touch. Third, he should note if the commutator is clean and the mica is

below the surface of the commutator bars. Fourth, he should see that the brushes have a good bearing and are not stuck, or light in the brush holder. Fifth, he should note if both main wires are held securely in the binding posts, and that the binding post screws are tight against the wires at both the dynamo and the lamp. Sixth, he should examine carefully where the wires may enter the pipes or the hand railing, the headlight case and the cab, and know positively that the insulation is in good condition on all wires both in and out of the cab. Seventh, he should note that there is a carbon of sufficient length in the lamp to make the trip, and that the clutch will lift the carbon at least $\frac{1}{4}$ of an inch from the point of the copper electrode. Eighth, he should see that the point of the copper electrode is clean and that it is pointed up with $\frac{1}{8}$ of an inch surface on the point, and that the electrode is not stuck in the holder. Ninth, he should see that the point of the copper electrode lines up true under the carbon.

TO FOCUS LAMP.

First.—Adjust back of reflector so front will be parallel with front edge of case.

Second.—Adjust lamp to have point of copper electrode as near center of reflector as possible.

Third.—Have carbon as near center of chimney hole in reflector as possible.

Fourth.—Have engine on straight track and move lamp until you get best results on track. The light should be reflected in parallel rays and in as small a space as possible.

To lower light on track raise lamp.

To raise light on track, lower lamp.

If your light throws any shadows it is not focused properly.

If light is focused properly and does not then strike center of track do not change focus, but shift entire case on base board. Point of copper electrode should be about one inch above top of holder. If it is higher than this, there will be too much heat on clutch.

QUESTIONS AND ANSWERS ON BUDA-ROSS ELECTRIC HEADLIGHT

Question 1.—What are the three essential elements in the Buda-Ross electric headlight equipment?

Answer.—The steam turbine engine, dynamo, directly connected on the same shaft and self-focusing arc lamp.

Q.—2. At what speed should the turbine run?

A.—About 2,800 revolutions per minute.

Q.—3. How is the speed controlled?

A.—By a centrifugal governing device.

Q.—4. How does the steam enter the turbine?

A.—Through a main valve, which is perfectly balanced in all steam pressures directly and impinged on the buckets directly from the nozzle.

Q.—5. About how much opening should this valve have?

A.—About one-fourth of an inch.

Q.—6. Can the lift of this valve be changed?

A.—Yes.

Q.—7. Explain how.

A.—By adjusting the inner sleeve of the valve with a common monkey wrench, after removing cap nut on top of turbine.

Q.—8. Can this be done while the light is burning?

A.—Yes, sir.

Q.—9. Explain how you would do it.

A.—With a monkey wrench screw the inner sleeve down to the right to reduce the lift and to the left to increase the lift. When you reduce the lift you reduce the speed, and by increasing the lift you increase the speed.

Q.—10. Is there any other way to change the speed?

A.—Yes, sir.

Q.—11. Explain how.

A.—Remove oil box on turbine cap and adjust the nuts on the governor studs on the face of wheel.

Q.—12. Is there any provision made for operating the light with low pressure steam?

A.—Yes, sir.

Q.—13. Explain how.

A.—An auxiliary valve is used which operates automatically at any predetermined pressure, which is adjusted by an adjusting stem at the bottom of the engine and which can also be adjusted while the light is burning.

Q.—14 What kind of oil should be used in the Buda-Ross bearings?

A.—Cylinder or valve oil.

Q.—15. What style of generator is used?

A.—An iron-clad type with no outside magnetism.

Q.—16. How many fields in this generator?

A.—There are two.

Q.—17. What style of field is used?

A.—What is known as compound wound.

Q.—18. What kind of wire is used on these fields?

A.—What is known as Delabeston wire.

Q.—19. Why is Delabeston wire used in preference to cotton-covered wire?

A.—So that it cannot be injured by short circuits, for if a short circuit occurs and then removed there is no damage done to the insulation on this make of wire.

Q.—20. Where are the fields located?

A.—One on each side of the dynamo.

Q.—21. Explain why.

A.—So that they cannot be injured by waste oil from the ball bearing, or by snow or water.

Q.—22. How should ball bearings on dynamo's end be lubricated?

A.—By removing oil plug in frame just back of dynamo and introducing cylinder oil.

Q.—23. Is it necessary to remove the top carbon holder from lamp to remove the reflector from case?

A.—No, sir.

Q.—24. Explain why not.

A.—Because there is no top guide to the carbon, as the carbon is guided by the clutches.

Q.—25. How many levers are there in the lamp?

A.—Only one.

Q.—26. What regulation should be given to top lever spring on lamp?

A.—Top lever spring should be adjusted as loose as possible and not have light go out standing still.

Q.—27. If this spring was tightened until the light burned steady when the locomotive was at rest what might occur when running at high speed?

A.—It might cause the light to dim down.

Q.—28. Is there anything else that would cause the light to dim down when the locomotive is running at high speed?

A.—If the clutches should be used until the sharp edge that grips the carbon has become worn smooth or round they would allow the carbon to feed too fast and the light would burn dim.

Q.—29. If the light burns all right while engine is in motion, but goes out when engine is at rest, where would you find the trouble?

A.—This trouble is most always caused by the top lever springs being too weak, or an imperfect carbon, though if the dash-pot plunger has become corroded until it sticks in the dash-pot the light will act the same as if the tension spring was too weak.

Q.—30. Is it possible to apply the bottom electrode holder wrong?

A.—No, sir.

Q.—31. Explain why not.

A.—For the reason that its support is on a center line with the electrode and the holder can be turned in any direction and the electrode is held central with the top carbon.

Q.—32. What would you do if you had no bottom electrode holder?

A.—Place a piece of ⅝-inch carbon in the hole through the bottom bracket having top end in focal point of reflector and tighten with set screw. As this carbon would burn away the light would be raised and it would be necessary to raise the carbon about every

hour, as the carbon would burn away about one-half inch per hour.

QUESTIONS AND ANSWERS ON SCHROEDER HEADLIGHT

Question 1.—What is the speed of a Schroeder headlight dynamo?

Answer.—About 2,800 revolutions per minute.

Q.—2. How is the speed changed?

A.—By a governor in the turbine.

Q.—3. How would you change the speed of the governors?

A.—Remove cover No. 3 and loosen lock nut No. 14 and turn nut No. 13 to the left to decrease and to the right to increase the speed.

Q.—4. Explain what is meant by the term a short circuit.

A.—A connection between the positive and negative wires of the dynamo without any resistance between.

Q.—5. How does the dynamo act when short-circuited?

A.—It will run very slowly as if under a heavy strain.

Q.—6. What would be the result if left to run under that strain?

A.—The armature or fields would burn out.

Q.—7. What would you do if a short circuit should develop while on the road?

A.—Would shut off steam and remove the positive or right hand wire of the cab circuit from the dynamo. start up and see if the light worked properly. If not, replace the cab wire and remove the left hand wire and see if the cab lights burned properly. If so, let it run, using the small incandescent light in the case for a headlight and report it at end of run.

Q.—8. What is the proper voltage of a Schroeder headlight?

A.—About 28 volts.

Q.—9. Can this voltage injure a person?

A.—No.

Q.—10. What is the proper amperage of a Schroeder headlight?

A.—About 30 amperes.

Q.—11. How often should the ball bearings be oiled?

A.—About three times a week.

Q.—12. How often should the governor be oiled?

A.—At beginning of every trip.

Q.—13. What kind of oil should be used?

A.—Valve oil.

Q.—14. Is it necessary to clean the electrode every trip?

A.—No.

Q.—15. Why not?

A.—The dynamo is provided with shunt fields which build up the current regardless of the arc light.

Q.—16. What causes the light to burn green?

A.—To high speed or wires to lamp being reversed.

Q.—17. If the carbons burned away too fast, but otherwise the lamp appeared to be burning properly, where would you look for the trouble?

A.—It would indicate that tripping spring No. 209 was too tight.

Q.—18. If tripping spring No. 209 was being annealed from heat and sparks were noticed at the clutch, where would you look for the trouble?

A.—The flexible wire No. 251 would be broken.

Mallet Compound, Great Northern Ry , Weight on Drivers, 350,000 lbs. Tractive Power, 70,000 lbs.; Length, 73 feet 2 inches.

QUESTIONS AND ANSWERS ON THE MALLET COMPOUND LOCOMOTIVE

Q.—1. What is a compound locomotive?

A.—An engine that uses the steam two or more times?

Q.—2. How many kinds of compounds are in general use?

A.—The tandem, the cross and the articulated compounds, the last generally called mallet compound.

Q.—3. When does a mallet compound have the most power?

A.—When being operated as a simple engine. It then has about 20 per cent. more power than when worked compound.

Q.—4. How many cylinders has a mallet or articulated compound?

A.—Four, two high and two low pressure cylinders.

Q.—5. Where are the cylinders located?

A.—The low pressure cylinders one on each side at front of boiler, and with the front set of driving wheels fastened to a frame, which is not rigid to boiler but is secured to the boiler by sliding bearings. The high pressure cylinder, one on each side, are located about the middle of the boiler, and with the back set of driving wheels attached to the frame and boiler in the usual manner.

Q.—6. How are the front and rear frames connected?

A.—With a hinged connection which allows the front set of wheels to swing when going around a curve, thus practically making the front group a truck, and from it the name articulated compound is derived.

Q.—7. How is an articulated compound made to operate simple or compound?

A.—By means of an intercepting and reducing valve and a separate exhaust often called an emergency valve.

Q.—8. Explain how a Mallet engine is operated in simple position.

A.—By turning a valve in the cab that allows steam to pass in front of the emergency valve, forcing it open. In this position all four cylinders are supplied with live steam from the boiler and the low pressure cylinders exhaust to atmosphere, and high pressure cylinders exhaust to the atmosphere through the receiver pipe and the emergency valve.

Q.—9. How is a Mallet compound operated in compound position?

A.—The valve in the cab is moved to compound position, which allows steam to escape in front of emergency valve, causing it to close. Main throttle is opened and steam passes to high pressure cylinders which exhaust direct to a receiver pipe, thus gradually building up a pressure, until this pressure is strong enough to automatically move the intercepting valve, allowing receiver pipe pressure to operate the low pressure cylinder. They are operated by live steam from the boilers through a pipe and reducing valve. This reducing valve is forced open by the live steam filling pipe leading to low pressure cylinders until its pressure is about one-half that of the live steam. Then the reducing valve automatically closes on account of its greater exposed area while in open position. As soon as low pressure cylinders exhaust the same process is repeated, and so on.

Q.—10. What are the advantages claimed for the articulated (or Mallet) compound?

A.—Much more tractive power with no increase in axle load. They can also round curves used by shorter engines.

Q.—11. When should the Mallet compound be operated as simple engine?

A.—Only when starting a train that cannot be started with engine in compound position or when about to stall.

Q.—12. How high should water be carried in the Mallet compound boiler?

A.—Never over two full gauges, while working, thus to keep the water from being carried into the intercepting valve while main throttle is open.

Q.—13. How should pistons and valves be lubricated?

A.—Feed more oil to the high pressure cylinders than the low, because the steam passes from high to low pressure cylinders and considerable oil with it.

Q.—14. When should a Mallet compound not be worked simple?

A.—Never when running faster than three or four miles per hour.

Q.—15. What should be done when engine is drifting?

A.—Open cylinder cocks and place reverse lever in about three-quarter stroke.

Q.—16. How should the intercepting valve be lubricated?

A.—Just before starting it should be oiled freely and periodically, where main throttle has not been closed for a long time. Otherwise one drop of oil every four or five minutes is enough.

Q.—17. What other parts not found on simple engines should be lubricated?

A.—Ball joint ahead of high pressure cylinders, rear ball joint of exhaust pipe, front ball joint of exhaust pipe, sliding boiler bearings on head engine, bolt of articulation between the two groups of wheels, ball

bearing of connecting bolts between frames, piston rod packing of power reversing gear, air cylinder of reversing gear, at least once a week.

Q.—18. How should valve and cylinder blows be located?

A.—Place engine in simple position, then blows can be located as on any locomotive.

Q.—19. Should any cylinder become disabled, what should be done?

A.—Disconnect and block as usual, then operate engine in simple, not running to exceed four or five miles per hour.

Q.—20. Is it a disadvantage to work a compound engine in short cut-off? Why?

A.—Yes. If cut-off is too short the proper proportion of steam passing the throttle will not get to the low pressure cylinders. The work of the engine should be divided between the two cylinders on the same side.

Q.—21. When starting the locomotive the forward engine does not take steam, what is the trouble?

A.—The reducing valve may be stuck shut on account of being dirty or stuck on the stem of the intercepting valve. In such case, the head of the dash-pot can be taken off and the valve worked back and forward to loosen it.

Q.—22. What is the duty of the by-pass valves on the sides of the low pressure cylinders? Should they be kept clean of gum and dirt?

A.—These valves are connected to the steam ports at each end of the cylinders and open to allow air and steam to pass from one end of the cylinder to the other away from the moving piston when drifting. When not kept clean they may stick open. When working steam the engine will blow badly. If they stick shut the engine will pound when drifting.

Q.—23. Why should the power reverse gear of the Mallet compound always have its dash-pot cylinder full of oil?

A.—To prevent the too rapid movement of the reverse gear piston and its damage.

Q.—24. What power is used with Ragonnet or Baldwin Power Reverse?

A.—Air pressure.

Q.—25. Can and should steam pressure be used?

A.—It can, but steam never should be used except in an emergency when air pressure is not available.

Q.—26. What care should be taken regarding steam check and throttle?

A.—See that they are tight and check working properly to insure that steam is kept from getting into main reservoir. For should it do so it would burn out the gaskets in the air brake equipment, allow the accumulation of moisture which in cold weather would cause the freezing and bursting of the equipment.

Q.—27. What would cause the gear to fail to hold links in intended cut-off and allow them to raise and lower without operating valve in cab being changed?

A.—Leaks in main valve and piston packing.

QUESTIONS AND ANSWERS ON OIL BURNING LOCOMOTIVES

Q.—1. What is an oil burning locomotive and where most generally used?

A.—A locomotive that uses oil for fuel instead of coal or other fuel is in most general use in oil producing districts and where long hauls make the cost of coal excessive.

Q.—2. What kind of oil is fuel oil?

A. Crude petroleum, or in some cases the residue that is left after crude petroleum has been refined.

Q.—3. In what way do crude oils differ?

A.—All crude oils contain a solid base of residue composed of hydrocarbons. In Ohio, Pennsylvania and West Virginia the base is a heavy paraffine, but in Texas and California and other Western oil producing states the base is a heavy asphalt. Crude oils with the paraffine base contain about 75 per cent of high grade oils, such as gasoline, benzine, naphtha and

kerosene, thus leaving only about 25 per cent fit for fuel oil, but the crude oils with the asphalt base have such a small amount of high-grade oils it does not pay to refine them. Therefore the product is almost entirely used as fuel.

Q.—4. What is meant by the flash point of crude oil?

A.—It means the lowest point of temperature that will ignite the oil.

Q.—5. For safety, what should be the flash point of crude oil?

A.—A minimum temperature of 140° fahrenheit, but much preferably 150° F.

Q.—6. How does crude oil compare as to value with coal as a locomotive fuel?

A.—From very exhaustive tests made on several western railroads, results show that it takes about 3½ barrels of crude fuel oil to equal one ton (2,000 lbs.) of coal.

Q.—7. Can oil be used with satisfactory results in the same type of firebox, grates, etc., as coal?

A.—No. Early experiments with this type showed that the grates allowed too much cold air to strike the flues, and the oil flames against the sheets of the firebox did not give satisfactory results.

Q.—8. How was these conditions remedied?

A.—The grates done away with and a closed pan used with a burner and air inlet at front end. The firebox being made large and fire-bricked at back end and sides so that flame from burner in front of pan is thrown against bricks in back of firebox, rebounding toward flues, thus preventing bad effect of oil flame against sheets. Also mixes the air and hydro-carbons better, giving much better combustion results.

Q.—9. Give description of apparatus for burning crude oil in a locomotive.

A.—Ilustration, Fig. 14, No. 2, shows turret on boiler head, and No. 3, blower pipe leading from same. No. 4, oil burning pipe connected with blower pipe in such manner that it can be operated with or without

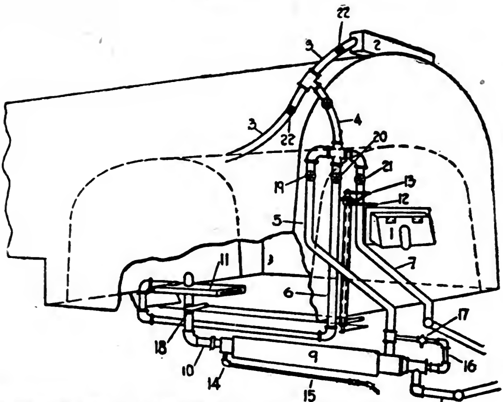


FIG. 14. LOCOMOTIVE OIL BURNING APPARATUS

NAMES OF PARTS			
1	OBSERVATION FIRE DOOR	12	HANDLE TO VALVE 18
2	STEAM TURRET	13	HANDLE TO DAMPER
3	BLOWER PIPE	14	WASTE PLUG TO SUPERHEATER JACKET
4	OIL BURNING PIPE	15	PIPING FOR WASTE PLUG
5	SUPERHEATER PIPE	16	BLOW BACK PIPING
6	ATOMIZING PIPE	17	BLOW BACK VALVE
7	HEATER PIPE	18	OIL VALVE TO BURNER
8	OIL PIPE FROM TANK	19	SUPERHEATER PIPE VALVE
9	SUPERHEATER	20	ATOMIZER PIPE VALVE
10	OIL PIPE TO BURNER	21	TANK HEATER PIPE VALVE
11	BURNER IN FIRE BOX	22	BLOWER PIPE VALVE

blower. No. 4, pipe is divided into three pipes, Nos. 5, 6 and 7. Pipe 7 connects with pipe on tank, and pipe on tank connects with pipe No. 8 on locomotive. These are the only oil burning device pipes between tank and engine, and are provided with flexible metallic piping, as rubber will not provide safety. No. 9 shows what is known as a superheater, which is a steam jacket surrounding the oil pipe which leads to burner 11 in firebox and heats the oil on its way to burner. Pipe 10 leads from superheater to burner, which is placed in front end of firebox with mouth away from flues. No. 12 is handle in cab that controls flow of oil to burner. No. 13 is handle in cab that controls damper just ahead of burner. There is a connecting clasp between these two handles, so they can be set to open or close in same manner. No. 14 shows location

of valve on lower front end of superheater and takes care of any condensation that may form in superheater. It is so arranged that this is allowed to pass out through pipe No. 15, and does not interfere with view of enginemen. No. 16 is known as the blow-back pipe, and No. 17 is the blow-back valve. No. 18 is oil regulating valve, and is operated in cab by means of handle No. 12.

Q.—10. Explain operation of oil burner.

A.—Always know that all oil pipes are tight and no oil dripping. Also that there is no accumulation of oil in firebox as this might explode and liable to burn whoever starts the fire. To successfully operate an oil burning device there must be at least 10 or 15 pounds of steam on boiler. At points where steam is not available through blower piping to start fire wood can be used to start fire till steam pressure shows on boiler of 10 or 15 pounds. Be careful and not injure firebrick in firebox when using wood. When 10 or 15 pounds shows on steam gauge turn on atomizing valve No. 6 and blow out any condensation that has accumulated in burner. At the same time turn valve No. 21 in pipe No. 7, which will allow steam to pass to tank heater. Close atomizer valve and throw a piece of oil saturated and lighted waste in back end of firebox, open atomizer valve slightly, and with care turn on oil at tank valve, and then by means of handle No. 12 in cab allow a small amount of oil to go to burner, where it will be sprayed on burning waste by the atomizer and will ignite. Now open damper in front end of closed ash pan by means of handle No. 13 in cab and regulate oil, atomizer and damper, according to work to be done, taking care to raise temperature in firebox slowly and not burn too much oil for the amount of air supply, or heavy black smoke will result.

Q.—11. Should oil pipes to burner become obstructed how can they be blown out?

A.—By closing oil feed valve on tank and waste valve No. 14 on superheater, open oil regulating valve No. 18 and blowback valve No. 17. Then open super-

heater valve No. 19 wide enough to remove obstruction.

Q.—12. How can obstructions be removed from oil feed pipe from tank?

A.—Close oil regulating valve No. 18 and waste valve No. 14 on superheater. Open valve on tank and valve No. 17 on blowback pipe, then open superheater valve No. 19, which will allow steam from pipe No. 5 to pass back into tank, thus removing the obstruction.

Q.—13. How should the heaters be used?

A.—The tank heater just enough to make the oil flow freely to the locomotive and the superheater just enough to make the oil atomize freely.

Q.—14. What care must be taken in or about the oil tank?

A.—Never have a flaming light about when filling oil tank and none should be placed inside a tank until it is empty and thoroughly washed.

SOME QUESTIONS AND ANSWERS ON THE WALSCHAERT, BAKER-PILLIOD, IMPROVED BAKER-PILLIOD AND HOBART-ALLFREE VALVE GEARS.

Question 1.—What is the meaning of the term valve gear or motion?

Answer.—The gear, or arrangement of rods, levers, etc., actuating the valve that admits steam from the boiler to the cylinders of an engine, and finally exhausts its therefrom, is called the valve gear or motion. It is the steam force in the cylinders that drives the piston which in turn, through connecting rods, forces the driving wheels to turn and move the locomotive. The gear includes the mechanism by which the locomotive may be reversed as to the direction in which it runs, by changing the steam distribution. The reversing mechanism is also employed to regulate the amount of steam admission to the cylinders and its retention there in proportion to the stroke of the piston.

Q.—2. What type of valve is required with the Walschaert style of gear?

A.—Any type of valve may be used, as with the link motion. The valve is not really regarded as a part of the valve gear.

Q.—3. What is the principal difference between the Walschaert gear and the Stephenson gear?

A.—Both gears use a link for reversing the motion or direction. In the Stephenson gear it is a floating link, of swing suspension; its motion imparted by two eccentrics attached to the main shaft or axle, and raising or lowering the link past its central position causes the reversion, while a slight shift up or down will shorten or lengthen the period of steam admission to the cylinders, because the valve receives its regular motion from a block carried in the slot of the

link. The Walschaert link is suspended by a fixed fulcrum pin or trunnion, located at the exact center of the link saddle, to which its oscillates, and cannot be raised or lowered. The link receives its motion from a single eccentric, the forward end of which is connected to an extension of the bottom of the link, and the back end is connected to the eccentric which is in the form of a return crank attached to the main crank pin, and set 90 degrees from it.

Q.—4. How many general types of valves are there in locomotive use?

A.—There are a great many styles of valves, but all of them are embraced within two general types, namely, slide valves and piston valves.

Q.—5. What is the theoretical position of the valve in relation to the piston with the two common types of locomotive valves most in use?

A.—With outside admission, the valve is always one-fourth of a cycle of motion or double stroke, ahead of the piston, while inside admission valves follow the piston the same distance.

Q.—6. How is lead obtained by the Walschaert gear?

A.—By the combination, or lap and lead lever.

Q.—7. How is the lap of the valve overcome in the Walschaert gear.

A.—By the combination, or lap and lead lever. Just the same as lead is obtained.

Q.—8. Does the amount of lead with the Walschaert gear remain the same at all points of the cut-off?

A.—Yes. The lead does not change at any point of the cut-off.

Q.—9. Is the Walschaert gear a direct or indirect motion?

A.—One might say both, and be right, for it is direct motion when the reverse lever is forward of the central notch of the quadrant and the radius rod below the center of the link, for there is then a direct, or unreversed line of motion from eccentric to valve,

the link acting as a single-arm rocker. It is of indirect motion with the reverse lever in any notch of the quadrant back of the center, as then the radius rod is carried above the link center, and the motion produced by the eccentric and transmitted to the lower end of the link by the eccentric rod, is reversed by the oscillation of the link, and the motion it delivers to the radius rod and valve is in an opposite direction to that received from the eccentric. The link in this case acting as a double-arm rocker.

Q.—10. Will the eccentric of the Walschaert gear give any movement to the valve when the engine is running if the reverse lever is in the center notch of the quadrant?

A.—No, for then the radius rod is being carried at the center of the link and will receive no motion.

Q.—11. Is it as easy to secure equal cut-off of admission of steam to each end of the cylinder with the Walschaert gear as with the link motion?

A.—Yes, in the Walschaert gear the opening and closing moments of the ports are accomplished with equal precision in each direction of the valve travel and cannot be otherwise for as the piston moves in either direction from the center of the cylinder it causes the combination lever to move the valve in an opposite direction with outside admission valves, and in the same direction with inside admission valves of the piston type.

Q.—12. Can you tell by the manner in which the radius rod is connected to the combination lever whether the valves are inside or outside admission?

A.—Yes. In all cases where the valves are of the outside admission type, the radius rod is connected to the combination lever below the valve stem; while, if the valves are of the inside admission type the radius rod is connected to the combination lever above the valve stem.

Q.—13. How would you change the lead of a valve with the Wa. chaert gear?

A.—Either change the lap of the valve, reducing it to increase the lead and increasing it to reduce the lead, or change the length of the arms or distances between the connecting points of the lap and lead lever. Increasing the distance between the radius rod connections and the valve stem connections to the lap and lead lever would increase the lead, or shortening this distance would decrease the lead.

Q.—14. Would changing the lead alter the cut-off?

A.—Yes, the cut-off would occur at later or earlier periods in the stroke depending on whether the lead was increased or decreased.

Q.—15. Why is the curve of the Walschaert link on a radius from ahead.

A.—As the radius rod by its attachment to the link block may be carried at any point in the link according to the direction of motion and the point of cut-off, raising or lowering the radius rod from the center would put it at an untrue angle with the link if the curve of the link were not towards the radius rod and of a radius equal to the length of the radius rod from its pin connection with the combination lever to the link-block pin.

Q.—16. Do the connections or bearings of the Walschaert gear have a tendency to heat in service?

A.—No. This gear is peculiarly free from any disposition towards heating.

Q.—17. With the Walschaert gear how may the valve be centered upon its seat so that with open throttle steam will not blow from the open cylinder cocks?

A.—With either inside or outside admission valves, when the crosshead is at the exact center of its travel with crank pin on the upper or lower working quarter, reverse lever in center notch of quadrant and the combination lever standing as it must in a plumb vertical position, its two upper connection pins on the same vertical line, then the valve is at the perfect center and covers all ports

Q.—18. On some types of Walschaert engines the eccentric crank is split so that it can readily be taken off, why is this construction used?

A.—In order to permit the use of a solid bushing on the side rod at the main crank pin connection.

Q.—19. Ordinarily what parts of this gear must fail that would necessitate putting the engine on one side?

A.—A broken radius rod or valve stem.

Q.—20. What particular thing should an engineer know in regard to an engine that is equipped with the Walschaert gear having the combination lever attached to the inner side of the crosshead?

A.—He should know whether or not the crank pin will clear the combination lever in all positions.

Q.—21. If you were handling an engine such as described in question 20, and broke the front section of either side rod, what would you do?

A.—Would take down the corresponding side rod on the other side and if, where the engine to slip, the front crank pin would not clear the combination lever in all positions, the engine would be totally disabled making it necessary to be towed in.

Q.—22. What would you do if you broke an eccentric crank?

A.—Would remove the broken parts that would strike or interfere, then would block the radius rod in the center of the link and disconnect the lifting rod on that side. If no lifting rod was used would take out the bolt connecting the radius rod to the arm of the tumbling or reverse shaft and proceed with the engine working on both sides.

Q.—23. In a case of this kind, what would impart movement to the valve on the disabled side?

A.—The movement of the valve would be imparted by the combination lever from the motion received from the crosshead.

Q.—24. How much valve movement and what port opening would your engine get?

A.—A movement equal to twice the lead and lap, and a port opening at each end of the cylinder equal to the lead of the valve, which ranges from 3-16 inch to 5-16 of an inch.

Q.—25. What precaution should be taken in a case of this kind when stopping the engine?

A.—Care must be used in stopping to see that the crank pin on the disabled side is not on either quarter, as in this case the combination lever would be in a perpendicular position and the valve would be central on its seat as the crank pin on the other side of the engine would be on the dead center it would be impossible to start the engine.

Q.—26. In case you did stop with the disabled side on the quarter how would you start the engine?

A.—Would shift the valve on disabled side, either by disconnecting the lower end of the combination lever and pulling it back or forward to open the port or take the blocks out (that I had put in the link) under the radius rod, which would allow the rod to drop to the bottom of the link, and would then move the link which would give me a port opening.

Q.—27. Name a point of difference between the Baker-Pilliod and the Walschaert valve gears and say what, if any, is the advantage?

A.—Unlike the Walschaert gear the Baker-Pilliod uses no link for reversing the motion, which eliminates the wear usual with the link.

Q.—28. In what two respects are the Baker-Pilliod, improved Baker-Pilliod and Hobart-Allfree valve gears similar?

A.—With all three gears the movement of the main valve is derived from an eccentric or return crank attached to the main crank pin and a combination lever connected by a union link to the crosshead.

Q.—29. Does the Hobart-Allfree gear use a link for reversing the motion?

A.—No, but uses a radius guide instead, on which slides a radius block which takes its place.

Q.—30. How are the connections made with the Baker-Pilliod, Improved Baker-Pilliod, and Hobart-Allfree gears?

A.—With pins and bushings.

Q.—31. How is directness of motion provided for and strains avoided with the Baker-Pilliod and Hobart-Allfree gears?

A.—With the Baker-Pilliod, by having the parts move in a straight line; and with the Hobart-Allfree gear by reason of the connections between the eccentric rod and the transmission bar being on a center line with the centers of the driving wheels.

Q.—32. Does variation of the engine on its springs cause the valves to get out of square with the Hobart-Allfree gear?

A.—No. Not so as to be noticed.

Q.—33. With the Hobart-Allfree gear does the breaking of springs have any effect on the valves?

A.—No. It has no noticeable effect.

Q.—34. Can you name some of the good features of the Baker-Pilliod gear?

A.—It allows of a very slight pre-admission, a quick port opening, and a quick closing to the valves, thus reducing compression.

Q.—35. How has the angularity of the eccentric rod with the Baker-Pilliod gear been overcome in the improved design of this gear, and what effect has these improvements on the valve events?

A.—By the use of a gear connection rod, by which it is possible to drop the front end of the eccentric rod to a point sufficient to minimize or eliminate all angularity. The valve events are more nearly square in all positions as the curved path of the front end of the eccentric rod common to the old gear has been done away with. The port openings may also be equalized in full gear, and a greater range of valve events may be produced by reason of the numerous modifications which may be made in the improved gear.

Q.—36. How does the bell crank with the improved gear differ from that of the old gear, and what advantage is gained?

A.—It now carries two vertical arms instead of one, and it is centrally hung from the frame. Its position has been shifted forward and its horizontal arm connects to the gear connection rod, while the vertical arms are on a line with the center of the combination lever, instead of as formerly having its upper, or horizontal arm connected to an eccentric arm and its lower or vertical arm connected to the valve rod. As improved it is possible to obtain sufficient valve travel on different classes of locomotives with the same bell crank instead of as formerly of having to use a variety of them.

Q.—37. In the improved Baker-Pilliod gear what effect does the changes in the reversing mechanism have on the position of the reversing yoke?

A.—The reversing yoke now lies forward in the go-ahead position instead of backward as in the old gear, that is it inclines in the direction in which the engine is to run.

Q.—38. With the improved gear what improvements were made as to lubrication?

A.—In place of the oil cups or oil holes of the old gear, all of the bearings are provided with an oil cavity which is integral with the part.

Q.—39. How are the Hobart-Allfree cylinders and steam chests constructed?

A.—The cylinder and steam chest is cast in one piece. The valve seat is close to the cylinder bore and is inclined at an angle of from 15 to 30 degrees, dependent upon the location of the valve stem. The steam chest and cover, as well as the cylinder heads, have heavy double walls with dead air spaces between them.

Q.—40. What is the double walls and air space used for in the Allfree cylinders and steam chests?

A.—By thus surrounding the live steam passages, the steam is thus protected to a great extent from sud-

den changes of temperature, with resulting condensation. It also makes the cylinders and steam chests much stronger by being so constructed.

Q.—41. What is the form of the compression valve used with the Allfree system of steam distribution?

A.—It is virtually a piston valve having solid heads and provided with wide snap rings.

Q.—42. How do they keep live steam from reaching the compression valve?

A.—By spanning the space between the bushions with a tube which makes a separate chamber.

Q.—43. What functions does the compression valve perform?

A.—It provides an increased exhaust area of about 50 per cent to that of the main valve.

Q.—44. What beneficial results are attained by this enlarged exhaust area?

A.—A quick, free opening which allows the expanded steam in the cylinders to almost instantly escape, thereby reducing the back pressure in the cylinders, and making it possible to run with a larger exhaust nozzle and maintain a proper fire.

Q.—45. What principal advantages are claimed for the Hobart-Allfree cylinders and valves?

A.—A saving in coal and water, increased power, higher speeds, and their adaptability to any type of locomotive, either old or new; or use in connection with any of the common valve gears in use.

Q.—46. What should be done in case of a broken crosshead yoke, crosshead arm, or union link, with the Baker-Pilliod or improved Baker-Pilliod gear?

A.—Would remove the broken parts and block the combination lever and proceed with the Baker-Pilliod gear. For the Improved Baker-Pilliod would take down the broken parts and secure the combination lever in such a position that its lower pin hole would be in a vertical line with the fulcrum pin of the bell crank and proceed.

Q.—47. What should be done in case of a broken crosshead yoke, crosshead arm or union link with the Hobart-Allfree gear?

A.—Would remove the broken parts, secure the combination lever in a vertical position by means of a piece of board or scantling fastened to the combination lever and the guide yoke and proceed.

Q.—48. What would you do in case of a broken reverse yoke, radius lifter arm, eccentric arm, or lower end of reverse arm with the Baker-Pilliod gear?

A.—Would remove the crosshead connections and the eccentric rod. Block the valve to cover the ports; arrange to lubricate the cylinder and proceed on one side.

Q.—49. What would you do in case of a broken gear connecting rod, radius bar, gear reach rod, or reverse yoke, with the Improved Baker-Pilliod valve gear?

A.—Would remove the broken parts, also the eccentric rod, secure the vertical arm of the bell crank in a perpendicular position and proceed with a port opening equal to the lead.

Q.—50. What would you do with a broken reversing link or reversing arm with the Hobart-Allfree gear?

A.—Would remove the broken parts, and with the reverse lever place the radius block in a position on the good side where the engine would start and handle the train, block the radius block on the side having the broken reversing link or reversing arm in a corresponding position and proceed.

SUPERHEATING STEAM AND DIFFERENT KINDS OF SUPERHEATERS

Superheating of Steam is a process for raising the temperature of steam after it has been generated. Stationary engines have long profited by this method and of late years locomotives have also come in for their share of the resultant economy derived from the superheating of steam. Although the principle itself has long been recognized, we cannot forget that there is often a wide divergence between practice and theory.

Other important advances were essential before the practical application to locomotives of superheated steam was possible. The most important of these included the adoption of balanced valves, metallic packing for valves and piston rods, higher flash oil for cylinder lubrication and more efficient lagging.

Requirements have been very stringent, however, as pertains to the superheater, because it had to meet very clearly defined conditions before it could be of any practical value.

The basic requisites that hedged in the adoption of the steam superheater to locomotive service may be summed up as follows:

In the first place simplicity of construction was necessary. Second, its application could not interfere with existing and necessary factors, such as the area of the heating surface. Third, it had to be easy of access for repairs in itself, or to the flues, such as their changing or cleaning. Fourth, it must not impose additional duties on the round house force or the engine crew. Fifth, it was necessary for its application to be as easy and economical to locomotives already in service as to new ones. Sixth, it must not interfere with the present designs of boilers in any very serious manner, and its cost must be moderate, and it must be able to stand considerable heat at times when no steam was passing through it. Seventh, although the conditions of work will vary between wide extremes, the super-

heater must be efficient and not subject to excessive wear and tear on account of these extreme variations. With the above essentials always in view, the Superheater has evolved. There are various types now in use on American locomotives. But the fact that the device **works** is its greatest endorsement.

These requirements imposed more complications on the superheater than might be supposed, but it has so successively overcome them that it is generally recognized as a great saver of both fuel and water.

The heat used for the superheater must be heat that would otherwise be wasted. In other words, the superheater must economize first of all as to its own source of heat, which is done by utilizing the waste gases. This does away with the necessity of changing the heating surface of the boiler or of changing its form.

The duties of the superheater are founded in its service in raising the temperature of the steam after it has ben generated in the boiler and before it passes into the cylinders.

It is an intermediary station between the engines dome and cylinders in which the energy of the fuel is given a fuller play, or in other words, water cannot be heated above 212 degrees F. Steam can to a great extent, as compared to saturated steam. Superheated steam contains some clearly outlined advantages. The superheated steam has not only greater temperature, but a greater specific volume than the saturated steam. The advantages accruing may be summed up in the increased volume, the diminution of cylinder condensation, the low thermal conductivity, the decrease in back pressure and the enhanced hauling capacity. As the temperature increases the specific volume of the steam decreases in so far as saturated steam is concerned. While in superheated steam its volume increases in nearly direct proportion to the rise in temperature. It has been demonstrated that for the same cut-off in the cylinder a specific volume of eighty degrees for the superheated means a 12 per cent saving,

as compared with saturated steam of the same pressure. Suppression of cylinder condensation is more far reaching value than the augmented volume. This is because with saturated steam in use a liberal percentage immediately precipitates without doing its quota of work, while the loss of energy in superheated steam is remarkably small. The fundamental reason for this is because superheated steam is a poor heat conductor—while saturated steam is an excellent heat conductor. In other words, the process of cooling the steam in the cylinders is nearly absent where superheated steam is used. With small volume and weight required in superheated steam, the back pressure is reduced in direct proportion. Piston speed and tractive increases also result, because of the tendency to complete gasification. The relative fuel and water savings thus secured are about 15 per cent for the former and from 8 to 12 per cent for the later.

In pasenger service is felt the full beneficience perhaps more than freight traffic, and with the use of smokebox superheaters, the train is picked up more quickly, is easier to handle and cares for a tonnage larger than where saturated steam is used.

The reduction in boiler pressures is one of the most pronounced endorsements of the smokebox superheater. Superheated steam means more power for the locomotive. By heating the cylinder walls lacking saturation and its attendant conductivity the endurance is increased and the amount of steam pressure required is diminished. In fine 160 pounds is found to be a safe mean upon which to base our estimates when dealing with superheated steam. This economy is applicable to both simple or compound locomotives. In connection with its use in the compound it has been estimated that superheated steam will bring about similar results in loss of cylinder condensation that are obtained by the triple expansion of steam without superheating.

It has been proven by carefully conducted tests, that locomotives equipped with superheaters require from 20 to 45 pounds less pressure than that needed

where saturated steam is used in the same type of locomotive. As to the amount of lubricant required, reports differ very much, some roads claiming that superheated steam needs from 5 to 20 per cent. more in lubricants, while other roads claim there is an actual saving in this item. At any rate, no change in the manner of lubrication has been called forth, and one engine on the New York Central finds an oil pump quite satisfactory.

Another form of direct economy has been found in the installation of the smokebox superheater in engines whose boiler plates are worn and whose flues are leaky through excessive high pressure. As to the degree of superheat required, that differs in various types, each having its own talking points to back its specific contentions.

The concensus of opinion as to the use of superheaters is that the mallet articulated compound lomomotives and the two cylinder compound locomotives require them to the point of necessity. In these classes of engines the condensation in the low-pressure cylinders is so excessive as to seriously impede the efficiency of the engine.

In the mallet compound the water works through the valves and cylinders, and does not stop with this damage, but often falls upon the rails, thus causing slipping of the forward group of drivers. By using a superheater for raising the temperature of the steam after it had done duty in the high pressure and before it enters the low-pressure cylinders this trouble is eliminated to a very great extent.

While some defects have been found, most of these have been remedied or overcome, and there is at present no record of where the use of the superheater has caused an increase in the cost of operation.

The use of superheated steam has been recommended in locomotives used on mountain roads, where the reduction of boiler stresses and the economy of fuel and water are very important.

DIFFERENT KINDS OF SUPERHEATERS.

There are a number of different types of superheaters in use, both in this country and abroad, the results of American tests is conceded to be more in keeping with solving American needs, and American engineers are not greatly concerned with what has been proven abroad, where types of locomotives often vary from those in use in America, and where the character of the road may also be much different. Some of the different types of superheaters now in use in this country and Canada are the Schmidt, the Cole, the Vaughan-Horsey and Baldwin. As our space is limited and as the main principles of the superheater all aim at the same end, we will only illustrate two of the kinds of superheaters now in most general use in this country and Canada, which are the Schmidt and the Vaughan-Horsey. The last named we give an illustration of in Fig. 1. It is extensively used on the Canadian Pacific Railroad, and is giving first class satisfaction.

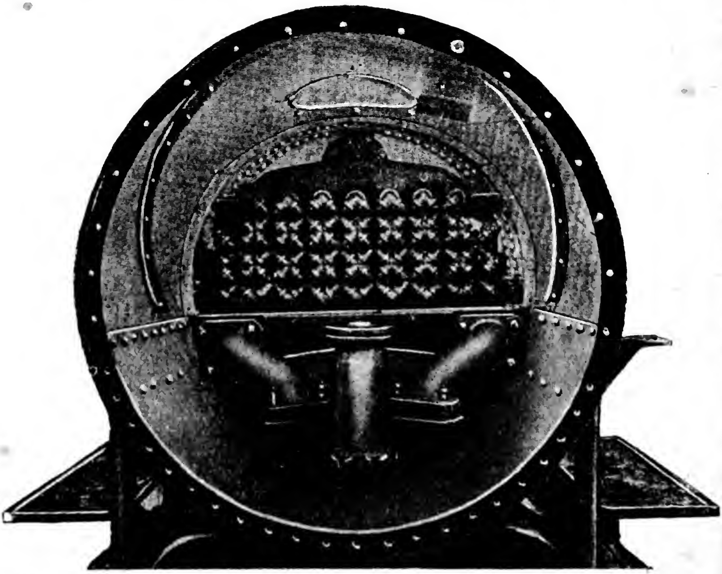


Fig. 1. The Vaughan-Horsey Superheater

THE SCHMIDT TOP HEADER TYPE SUPERHEATER

Which is in most general use on railroads in the United States, and which seems to be giving generally good results. We will illustrate and explain this type as it will probably be of more value to my readers than any other. The Schmidt Top Header type of superheater herewith shown contains 30 elements. The term, elements, used in connection with a superheater, means one complete loop of one of the small superheater steam pipes. With a superheater of this type each element or superheater tubes is contained in one large

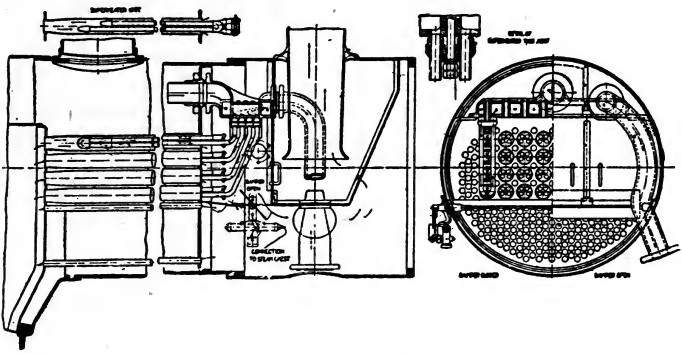


Fig. 1. Top Header Superheater

smoke tube, which is exactly the same as the ordinary boiler tube or flue, except that it is larger in diameter. The superheater smoke tubes shown in this illustration are 5⅜ inches in diameter. By referring to Figs. 1 and 2 the general design and operation of this type of superheater is made plain. At the left, above Fig. 1, is shown one superheater element or unit complete, which comprises the smoke tube and the superheater tubes

within it. It will be seen that the superheater tube makes one complete loop, so that the steam entering the header or nigger head from the dry pipe passes into one end of the superheater tube, flows back to the rear and then forward again, making a turn at the front flue sheet, goes back again and then forward and out into the second compartment of the header, from whence it flows into the steam pipes. Upon opening the throttle the steam passes through the dry pipe, and on reaching the header is forced through the passage W, Figs. 1 and 2, to the various units forming the

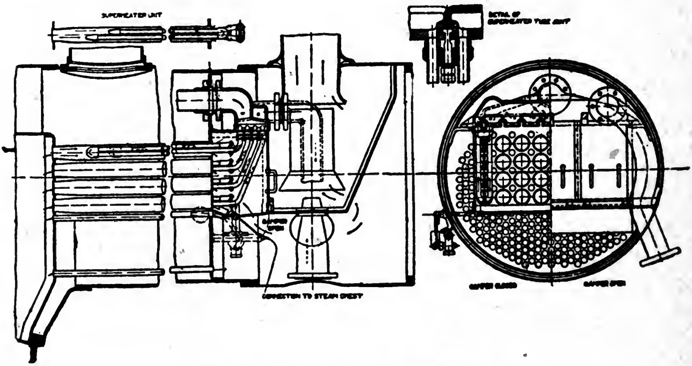


Fig. 2. Top Header Superheater

superheater. After passing through these superheater units the steam is delivered to the passage S, from which it passes to the steam pipes and steam chest. A small steam pipe connects the main steam pipe or steam chest with the superheater damper cylinder, and when the main throttle is opened so that the steam chest or steam pipes are filled with steam, the steam flowing up through the small steam pipe acts on the piston of the superheater damper cylinder and opens the damper, thus permitting the free flow of hot gases

from the fire to the smokebox through the large boiler flues which contain the superheater tubes.

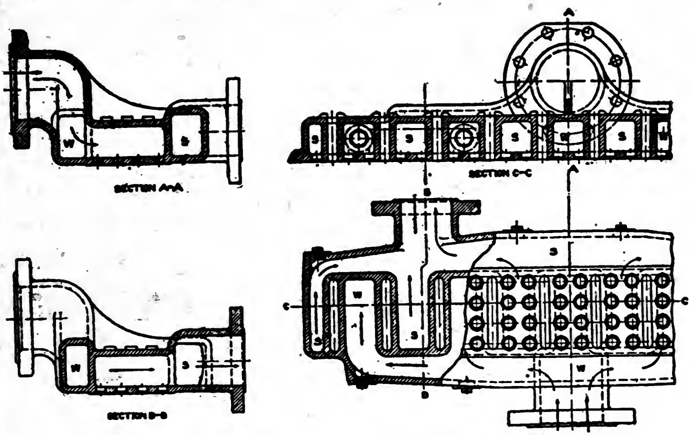


Fig. 3. Superheater Header

Both illustrations show the damper open, as soon as the main throttle is closed, and no more steam remains in the steam chest or pipes, the steam flows out of the superheater damper cylinder, and a counter-weight, (shown in dotted line, Figs. 1 and 2) drops down, closing the damper. This is one point that engineers and firemen operating engines using superheated steam should watch, that is, to see that the damper opens when opening the main throttle and closes promptly when closing it. Otherwise, if the damper was to remain open when the throttle is closed the hot gases from the fire passing around the superheater elements would have a tendency to overheat and thus damage them. The working of the damper can be easily seen by watching the counter-weight, which should be up when the throttle is open and down when the throttle is closed. Fig. 3 shows various

views of the header, or nigger head, showing the different passages, S and W, with the connections to steam pipes and dry pipes. Fig. 4, shows two views of the damper arrangements, one with the damper open, the other with damper closed.

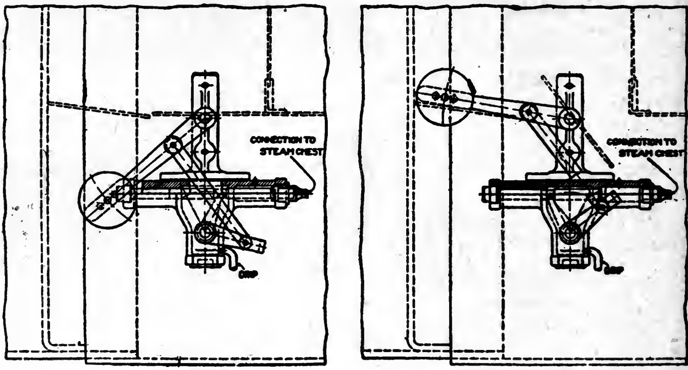


Fig. 4. Superheater Damper Arrangements

FRANKLIN VERTICAL LIFT FIRE DOOR

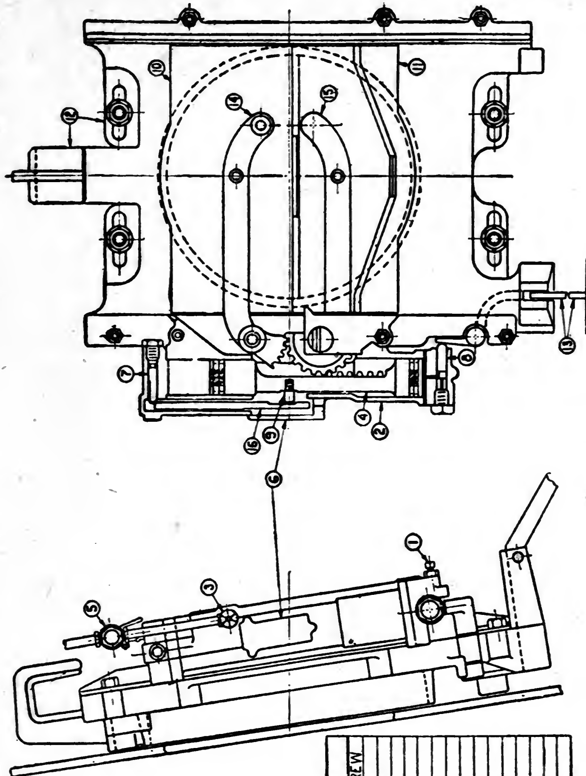


Fig. 1. Franklin Vertical Lift Fire Door

	NAME OF PARTS
1	AIR CUSHION ADJUSTING SCREW
2	CYLINDER
3	NEEDLE VALVE
4	PISTON
5	STRAINER VALVE
6	TRIP CASE COVER
7	VALVE - UPPER
8	VALVE - LOWER
9	VALVE TRIP
10	DOOR - UPPER
11	DOOR - LOWER
12	FRAME
13	FOOT PEDAL
14	OPERATING ARM - UPPER
15	OPERATING ARM - LOWER
16	VALVE TRIP ROD

Figure No. 1 is an illustration of the Franklin Vertical Lift Fire Door. The pipe near strainer No. 5 leads from main reservoir connection. The air passes

through strainer No. 5 down through needle valve No. 3 and at that point leads into air ports which provide main reservoir air pressure into space around lower valve No. 8. Foot pedal No. 13 is so located that the fireman with his accustomed swing in putting the coal into the firebox places his left foot on the pedal, which opens valve No. 8, admitting air into the cylinder through the small port shown and against the lower head of piston No. 4. This forces the piston upward. The rack on piston No. 4 engages the segments on upper and lower operating arms No. 14 and 15, which in turn engages with the upper and lower door leaves No. 10 and 11. This movement raises door No. 10 and lowers door No. 11, permitting the fireman with the same swing to deliver the coal into the firebox. Piston No. 4 on its upward movement carries with it valve trip No. 9, which engages with valve trip rod No. 16 at the upper shoulder. This in turn moves upper valve No. 7 to the right, admitting air into the top of cylinder No. 2, which returns piston No. 4 to the lower part of the cylinder, causing the doors to close. The air cylinder adjusting screw No. 1 is used to regulate the speed that opens and shuts the door. The principle is that the end of the adjusting screw restricts the flow of air through the port when leading into cylinder No. 2. The speed of the door may be hastened by feeding the screw outward and slowed by feeding it inward. This type of door, like the one in Fig. 2, has many advantages over the swing doors. It alows the fireman to deliver the coal into the firebox with two movements namely, filling the scoop and delivering the coal, the door being opened, as told above, by placing the left foot on pedal, with the accustomed swing of the body when delivering coal to the firebox. This door is safe, should a flue burst in the firebox, as the positive pressure would close the door and hold it, unless the frame is forced off of the studs that hold it in place to the boiler head. It also reduces the amount of cold air that is fed into the firebox during the process of firing to a minimum and automatically regulates the one-scoop

method of firing, as it automatically closes after each scoopful of coal is delivered. A handle is provided on operating arm No. 14 by which the door may be opened or closed when the air is not turned on. Air cushion adjusting screw No. 1 can be so adjusted that the door will not slam when opening or shutting.

THE FRANKLIN BUTTERFLY FIRE DOOR

Figure 2 is an illustration of what is known as the Franklin Butterfly type of fire-door. This has the same advantages as the lifting type of door, and an additional advantage claimed for it is that it is not so apt to slam when closing as the vertical lift door is. It is designed so that when the door plates have opened the proper distance the connecting link is on a dead center with the piston connecting link and door bolt. This arrangement stops the door without any jar or slam. The door is operated by air, which is admitted through globe valve No. 10, strainer valve No. 12, down to operating valve No. 1. The operator, with his accustomed swing in delivering coal, places his foot on pedal No. 4. Valve No. 1 is raised from its seat, allowing air pressure to pass to the left end of the cylinder. The piston No. 8 is carried forward by this pressure and transmits this movement to the door through link No. 7, which is attached to the left hand door plate. The two plates are connected by two intermeshing gear teeth. As the piston moves forward the door plates are caused to rotate around the fulcrum pin until they have uncovered the opening in the door frame, (as shown in dotted lines) at which time the connecting link is straightened out and the link connections on the left hand door is in a direct line with the center of the door and the connection on the piston. This arrangement provides a gradual stopping of the piston and door without hammer blows. When the fireman removes his foot from lever No. 4, valve No. 1 will seat, thus cutting off air admission to the cylinder and permits the air in the cylinder to exhaust. The weight of the doors will then close them automatically,

bringing the piston back to its normal position in the cylinder when the doors are closed.

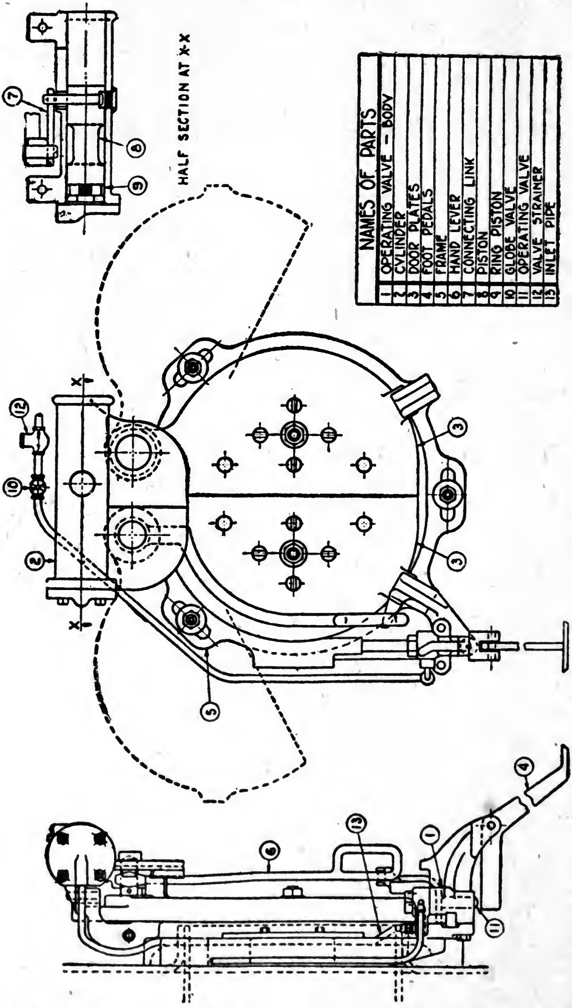


Fig. 2. Franklin Butterfly Door

	NAMES OF PARTS
1	OPERATING VALVE — BODY
2	CYLINDER
3	DOOR PLATES
4	FOOT PEDALS
5	FRAME
6	HAND LEVER
7	CONNECTING LINK
8	PISTON
9	RING PISTON
10	GLOBE VALVE
11	OPERATING VALVE
12	VALVE STRAINER
13	INLET PIPE

There is a hand lever, No. 6, provided to operate doors. When there is no air pressure a latch is

provided which has two notches to engage the hand lever. The first notch holds the door open about eight inches at the bottom. This allows the admission of air to the firebox while the engine is standing at rest. The other notch is located so as to hold the door full open. The leaves or plates of the door are of hollow construction, providing the free circulation of air within them, admitting heated air to the firebox, which aids combustion. A removable baffle plate is provided to facilitate repairs. Care should be taken to see that arrow on strainer valve No. 12 points towards globe valve No. 10. The pipe leading to main pressure reservoir should be screwed into the end of the strainer valve, as shown by the broken section. There is a plug or cap provided on the top of this strainer valve for cleaning and refilling the strainer with mattress hair which acts as a strainer.

A FEW HANDY POINTERS IN ARITHMETIC

To find the revolutions of driving wheels per mile divide 1680 by the diameter of the wheel in feet.

To find revolutions per minute multiply the speed in miles per hour by 28 and divide the product by the diameter of the driving wheel in feet.

To find the circumference of a circle multiply its diameter by 3.1416.

To find the diameter of a circle multiply its circumference by .31831.

To find the area of a circle multiply the square of its diameter by .7854.

To find the cubic inches in a ball multiply its cube of diameter by .5236.

To find the number of tons of coal in a bin, length, height and width of pile in feet multiplied together, divide by 30 for hard coal, and by 35 for soft coal; by 128 for cords of long wood, and by 135 for cords of stove length wood.

To find piston speed in feet per minute multiply revolutions per minute by twice the stroke of piston in feet.

To find the speed of a train per second multiply speed in miles per hour by 22 and divide by 15.

To find time when rate of speed and distance is given multiply distance by 60 and divide by rate of speed.

To find rate of speed when distance and time are given, distance multiplied by 60 and divided by the time in minutes.

To find the distance when the time and rate of speed are given multiply the time by the rate of speed and divide by 60.

LOCOMOTIVE TRACTIVE EFFORT

According to the latest ruling of the Interstate Commerce Commission, Locomotive Tractive Effort can be figured with the following formula: Diameter of cylinders, squared, times stroke times 85% of boiler pressure divided by the diameter of driving wheel in inches.

HORSE-POWER OF A LOCOMOTIVE

Horse power is the measure of the rate at which work is performed and is equal to 33,000 pounds lifted 33,000 feet in one minute or one pound lifted 550 feet in one second, therefore one horse power equals 550 foot-pounds per second.

To find the horse power of a locomotive multiply the tractive power of a locomotive by the speed in miles per hour, divided by 375.

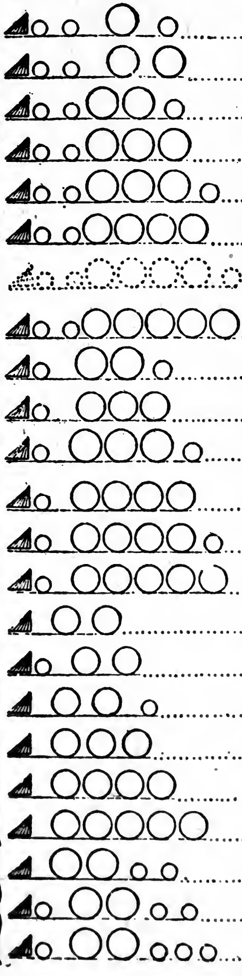
HEATING SURFACE OF BOILER TUBES

L'gth In Feet	Heating Surface in Sq. Ft. Outside Diameter 1½ in.	1¾ in.	2 In.	2¼ In.	L'gth In In.	Heating Surface in Sq. Ft. Outside Diameter 1½ in.	1¾ in.	2 In.	2¼ In.
5	1.964	2.291	....	....	¼	0.008	0.009	0.011	0.012
6	2.356	2.749	3.142	....	½	0.016	0.019	0.022	0.025
7	2.749	3.207	3.665	....	¾	0.025	0.029	0.033	0.037
8	3.142	3.665	4.189	....					
9	3.534	4.123	4.712	....	1	0.033	0.038	0.044	0.049
10	3.927	4.582	5.236	5.891	2	0.066	0.076	0.087	0.098
11	4.320	5.040	5.760	6.480	3	0.098	0.115	0.131	0.147
12	4.712	5.498	6.283	7.069	4	0.131	0.153	0.175	0.196
13	5.105	5.956	6.807	7.658	5	0.164	0.191	0.218	0.245
14	5.498	6.414	7.330	8.247	6	0.196	0.229	0.262	0.294
15	5.891	6.872	7.854	8.836	7	0.229	0.267	0.305	0.344
16	....	7.320	8.378	9.425	8	0.262	0.305	0.349	0.393
17	....	....	8.901	10.014	9	0.295	0.344	0.393	0.442
18	....	....	9.425	10.603	10	0.327	0.382	0.436	0.491
19	....	....	9.948	11.192	11	0.360	0.420	0.480	0.540
20	....	....	10.472	11.781	12	0.3927	0.4582	0.5236	0.5891
21	....	....	10.995	12.360					
22	....	....	11.519	12.959					

SPEED TABLE of Miles Per Hour at a Given Time Per Mile

Time per mi. M.	S.	Miles per hr.	Time per mi. M.	S.	Miles per hr.	Time per mi. M.	S.	Miles per hr.	Time per mi. M.	S.	Miles per hr.	Time per mi. M.	S.	Miles per hr.
0	35	100.	0	58	62.07	1	20	45.	1	42	35.29	2	4	29.03
0	37	97.30	0	59	61.02	1	21	44.44	1	43	34.95	2	5	28.80
0	38	94.73	1	0	60.00	1	22	43.90	1	44	34.61	2	6	28.57
0	39	92.31	1	1	59.02	1	23	43.37	1	45	34.29	2	7	28.34
0	40	90.00	1	2	58.06	1	24	42.86	1	46	33.96	2	8	28.12
0	42	85.21	1	4	56.25	1	26	41.86	1	48	33.33	2	10	27.69
0	43	83.72	1	5	55.38	1	27	41.38	1	49	33.03	2	11	27.48
0	44	81.82	1	6	54.55	1	28	40.91	1	50	32.73	2	12	27.27
0	45	80.00	1	7	53.73	1	29	40.45	1	51	32.43	2	13	27.09
0	46	78.26	1	8	52.94	1	30	40.00	1	52	32.14	2	14	26.87
0	47	76.59	1	9	52.17	1	31	39.56	1	53	31.86	2	15	26.67
0	48	75.00	1	10	51.43	1	32	39.13	1	54	31.58	2	16	26.47
0	49	73.47	1	11	50.70	1	33	38.71	1	55	31.30	2	17	26.28
0	50	72.00	1	12	50.00	1	34	38.29	1	56	31.03	2	18	26.09
0	51	70.59	1	13	49.31	1	35	37.89	1	57	30.77	2	19	25.90
0	52	69.23	1	14	48.65	1	36	37.50	1	58	30.51	2	20	25.71
0	53	67.92	1	15	48.00	1	37	37.11	1	59	30.25	2	21	25.53
0	54	66.66	1	16	47.37	1	38	36.73	2	0	30.00	2	22	25.35
0	55	65.45	1	17	46.74	1	39	36.36	2	1	29.75	2	23	25.17
0	56	64.29	1	18	45.15	1	40	30.00	2	2	29.52	2	24	25.00
0	57	63.16	1	19	45.57	1	41	35.54	2	3	29.27	2	25	24.83

CLASSIFICATION OF LOCOMOTIVES
Whyths System



	Type Name.	Whyte's System.	Total Wheels.
Bogie Class	SINGLE DRIVER	4-2-2	8
	EIGHT-WHEEL (American)	4-4-0	8
	ATLANTIC	4-4-2	10
	TEN-WHEEL	4-6-0	10
	"ST. PAUL"	4-6-2	12
	TWELVE-WHEEL	4-8-0	12
	"PHANTOM" (Non Existent)	4-8-2	14
	MASTODON	4-10-0	14
Pony Class	COLUMBIA	2-4-2	8
	MOGUL	2-6-0	8
	PRAIRIE	2-6-2	10
	CONSOLIDATION	2-8-0	10
	"CALUMET"	2-8-2	12
	DECAPOD	2-10-0	12
Switcher Class	4-WHEEL SWITCHER	0-4-0	4
	4-COUPLED SWITCHER	2-4-0	6
	4-COUPLED SWITCHER	0-4-2	6
	6-WHEEL SWITCHER	0-6-0	6
	8-WHEEL-SWITCHER	0-8-0	8
	10-WHEEL-SWITCHER	0-10-0	10
Forney Class	FORNEY (original)	0-4-4	8
	MOGUL-FORNEY	2-4-4	10
	FORNEY-SUBURBAN	2-4-6	12

DIAGRAM OF CLASSES OF LOCOMOTIVES

NAMES APPLIED TO THE VARIOUS TYPES OF LOCOMOTIVES

The origin of the different names by which certain types of locomotives have become familiarly known and designated, the writer is unable to tell, they having been suggested by the builders or some other individual and gradually came into general use. At present, however, these names are a part of the locomotive vocabulary.

The accompanying illustration gives the arrangement of truck and driving wheels and their names and class as they are known to the railroad world.

(See page 358.)

TABLE OF WATER AND COAL WEIGHTS AND MEASURES

Water—One cubic inch weighs .036 pounds. One cubic foot at 32° F. weighs 62.4 pounds, and contains 7.4 United States gallons. One gallon U. S. standard contains 231 cubic inches and weighs 8⅓ pounds. One gallon imperial contains 277¼ cubic inches and weighs 10 pounds.

Coal—Average weight of one cubic foot:

Bituminous, large size	52	pounds
Bituminous, run of mine	54	pounds
Anthracite, large size	54	pounds
Anthracite, buckwheat	52	pounds

Average weight of one bushel containing 2,500 cubic inches:

Bituminous	75	pounds
Anthracite	78	pounds

Specific gravity:

Bituminous	1.40	
Anthracite	1.60	
Average bulk of one ton	2240	pounds
Bituminous	43	cubic feet
Anthracite	41.5	cubic feet

Coal—Grade Divisions:

Anthracite, all coal with less than 7:5 per cent volatile matter incombustible.

Semi-Anthracite, all coal with 7.5 per cent to 12.5 per cent volatile matter incombustible.

Semi-bituminous, all coal with 12.5 per cent to 25 per cent volatile matter incombustible.

Volume and Weight of Crude Petroleum

Pounds	U. S. Liq. Gal.	Barrel	Gross Ton
1	.13158	.0031328	.0004464
7.6	1.	.02381	.003393
319.2	42.	1.	.1425
2240.	294.72	7.017	1.

Fuel consumption:

Assuming that one-half stroke cut-off represents the average work of the cylinders for a given run, the water consumption will be about 25 pounds or 3 gallons per horse power per hour, and the consumption of coal about one pound per gallon of water or 3 pounds per horse power.

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